OPERATING MANUAL

FIREBERD

DATA ERROR ANALYZER

Telecommunications Techniques Corporation

...EXPECT EXCELLENCE

IMPORTANT

Please return the enclosed card so TTC may ensure that product updates, application notes, and new product information reaches the users of our equipment.

ML10278
Rev. D

FIREBERD 1500A
OPERATING MANUAL

June 1987

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MANUAL ABSTRACT

This Operating Manual comprises nine sections and two appendices. Each manual section is briefly described below.

Section 1 GENERAL INFORMATION

This section contains general information relating to the FIREBERD 1500A including: instrument identification, specifications, instrument description, equipment supplied, options, accessories, and ordering information.

Section 2 PREPARATION FOR USE

Unpacking and initial inspection instructions, warnings, and power requirements are contained in this section.

Section 3 INSTRUMENT CHECKOUT

This section provides an instrument checkout procedure for manually checking the operation of the FIREBERD 1500A.

Section 4 INSTRUMENT DESCRIPTION

A detailed description of each control, indicator, connector, and test point on the instrument is provided.

Section 5 OPERATION

This section contains operating information including: measurement capability, measurement configurations, operating considerations, and an operating procedure.

Section 6 PRINTER INTERFACES AND PRINTOUT FORMATS

This section describes events which initiate data outputs, data output formats, and data buffering for the RS-232 and IEEE-488 Printer Interfaces. A physical and signal format description for the RS-232 interface is also provided. Information related to remote control of the FIREBERD 1500A via the RS-232 or IEEE-488 interfaces (option 007 and 008) is not provided in this manual but is provided in a separate manual, Number ML10491.

Section 7 INTERFACE MODULES

Descriptions, specifications, and operating instructions are provided for 13 different interface adaptor modules. Less frequently used interface modules are described in separate, individual manuals.

Section 8 OPTIONS AND ACCESSORIES

Options and accessories available for use with the FIREBERD are described.

Section 9 MAINTENANCE AND SERVICE

Warranty, servicing, and shipping information are provided in this section.

APPENDIX A

This appendix provides a list of abbreviations.

APPENDIX B

The optional sync loss feature is described here.

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SECTION 1
GENERAL INFORMATION

1.1 INTRODUCTION

This Operating Manual contains information required to install and operate the FIREBERD 1500A and FIREBERD 1500A-1 Data Error Analyzers. This manual also covers the metal versions of each of the above units, the MC1500A and MC1500A-1.

The FIREBERD 1500A and FIREBERD 1500A-1 are functionally identical. The only difference between the units is that the 1500A-1 has predefined clock frequencies in place of the optional generator clock rates of the 1500A. Section 4.2.1 lists the clock frequencies available for each unit.

Unless otherwise stated, references to the FIREBERD or the FIREBERD 1500A also apply to the FIREBERD 1500A-1, the FIREBERD MC1500A-1 and the FIREBERD MC1500A.

1.2 INSTRUMENT IDENTIFICATION

An identification sticker is attached to the rear panel of each instrument. The serial number on this plate should be quoted on any correspondence with TTC.

1.3 SPECIFICATIONS

1.3.1 Measurement Capability

- Measurements: BER, errors, blocks, block errors, errored seconds, seconds of testing, error free seconds, percent error free seconds, and elapsed time since power-up.

- BER Test Lengths:
  Fixed Lengths — 10^5, 10^6, 10^7, 10^8, 10^9, and 10^{10} bits.
  Auto Ranging Lengths — 10^5, 10^6, 10^7, 10^8, 10^9, and 10^{10} bits.

- Block Lengths: 10^3, 10^4, and 10^5 bits.

1.3.2 Operating Rates

- Speed Range: 50 Hz to 13 MHz[1].

1.3.3 Measurement Ranges and Result Display

- Errors, Blocks, Block Errors Errored Seconds, and Seconds: Results are displayed with six decimal digits. All decimal points illuminate and display flashes when displayed result has overflowed.

- BER: Result is displayed with a three-digit mantissa and a two-digit exponent. Results range from 0 x 10^{-10} to 1.00 x 10^{-0}. (Internal counters are large enough to prevent overflow under any circumstances.)

- Elapsed Time, Error Free Seconds, and Percent Error Free Seconds: Elapsed time since power-up, error free seconds, and percent error free seconds are available for printout only and may not be displayed.

[1] See Section 5.4.7 for measurement limitations.

- Display Hold: The result currently being displayed as well as all other results selectable with the DISPLAY switch may be held indefinitely for display. Testing continues while the display is in hold mode.

1.3.4 Patterns and Data Outputs

- Pseudorandom Patterns: Sequences of length 63, 511, 2047, 2^{15}-1, and 2^{20}-1 are available. All patterns may run in the normal or reverse direction and any pattern may be inverted.

- Fixed Patterns: Constant Mark, alternating Mark-Space (1:1), and one Mark followed by three Spaces (1:3) are available. Any pattern may be inverted.

- Error Insert: Single errors or a constant 1×10^{-3} error rate may be inserted into the outgoing data.

1.3.5 Timing System

- Timing Modes: With the appropriate interface module, the unit will operate with synchronous, character (asynchronous), or isochronous (recovered) timing.

- Internal Standard Clocks:
  1500A Frequencies: 1.2, 2.4, 4.8, 9.6, 19.2, and 56 kHz.
  1500A-1 Frequencies: 1.2, 2.4, 4.8, 9.6, 19.2, 48, 56, 60, 64, and 72 kHz. 192., 256, 512, 768
  Accuracy - ± 1 ppm at 25° C.
  Stability - ± 5 ppm 0° C to 40° C.

- Internal Optional Clocks:
  Frequency: 100 Hz to 13 MHz (customer specified).
  Accuracy: ± 1 ppm at 25° C.
  Stability: ± 5 ppm 0° C to 40° C.

- External Clock from Interface Module:
  Any square wave clock meeting the requirements of the applicable interface specification.

- External Clock from BNC Input:
  Frequency: 50 Hz to 13 MHz.
  Waveform: Sine or square wave, unipolar or bipolar.
  Level: 1.0 ^{V}p-p to 25 ^{V}p-p.

1.3.6 Emulation Capability

With the appropriate interface module, the FIREBERD 1500A will emulate data terminal equipment (DTE) or data communications equipment (DCE).

1.3.7 Available Interfaces[1]

RS-232 Sync DTE/DCE
RS-232 Sync/Isoch DTE
RS-232/V.24/MIL-188C Character DTE/DCE
V.35/306 DTE/DCE

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[1] Contact TTC for an updated list of available interface modules.

RS-449/422/423 DTE/DCE
T1 D4 (Framed/Unframed)
T1 (Unframed) with APS
WECO 303
LAB (TTL)
Military MIL-188C/MIL-188-114 Unbalanced
Military MIL 188-114 Balanced
CCITT G.703 64 kb/s Codirectional
CCITT G.703 2.048 Mb/s

1.3.8 Indicators

- Indicators Provided in Both Emulate DTE and DCE Mode:
  - Power
  - Sync
  - Sync Lost
  - Loop Test
  - Emulate DTE
  - Emulate DCE

- Provided in Emulate DTE Mode:
  - Transmit Clock Activity
  - Receive Data Inverted
  - Receive Data Mark
  - Receive Data Space
  - Receive Clock Activity
  - Data Set Ready/Data mode
  - Receive Line Signal Detect/ Receiver Ready
  - Clear to Send

- Provided in Emulate DCE Mode:
  - Receive Clock (Generator Clock) Activity
  - Transmit Data Inverted
  - Transmit Data Mark
  - Transmit Data Space
  - Transmit Clock Activity

Data Terminal Ready/Terminal Ready
Request to Send
Local Test/Local Loop

- Audio Indicator: An internal audio indicator beeps on the occurrence of errors and sync losses in Single or Block mode, and on BER measurement completion and sync losses in BER mode. Volume may be set to low, high, or off.

1.3.9 Events Initiating Printouts:

Printouts are initiated automatically at the completion of the BER measurement in BER mode. In Single or Block mode, printer controls allow printouts to be initiated on 1, 10, or 30 minute intervals, or on the occurrence of an errored second and every hour. In any mode, printouts may be initiated manually and will be automatically initiated on power-on, sync acquisition, sync loss, receiver clock loss, and counter overflow.

- RS-232 Printer Interface: This interface allows output to a printer or terminal according to the EIA RS-232C interface specification. A rear-panel DIP switch allows data to be output with: 1 or 2 stop bits; even or odd parity; carriage return or carriage return and linefeed terminating each line; and at 300, 600, 1200, or 2400 Baud. Data is output coded in ASCII and all data outputs are labeled in plain English. The TTC PR-2000 Alphanumeric Thermal Printer is directly compatible with this interface.

- IEEE-488 Interface (Option): This interface allows the FIREBERD to directly output to a 488 compatible printer in Talk Only mode or to act as an "Addressable Listener" in a multi-instrument 488 bus configuration.

1.3.11 Rear-Panel Test Points

The following open-collector TTL outputs with pull-up resistors are provided:

Transmit-pattern sync, receive-pattern sync, error, transmit clock - DTE source, transmit clock - DCE source, receive clock, receive data, transmit data, and ground.

1.3.12 Physical Characteristics

- Size (approximate):

Plastic Case (1500A)	6" H x 12" W x 12" D (15.24 cm x 30.48 cm x 30.48 cm).
Metal Case (MC1500A)	6.5" H (including feet) x 14.2" W x 14" D (with cover) (16.51 cm x 36.07 cm x 35.56 cm).

- Weight (approximate) with Interface Module:

Plastic Case (1500A)	10 lbs (4.536 kg) (with cover).
Metal Case (MC1500A)	18 lbs (8.165 kg) (with cover).

1.3.13 Power Requirements

- Switch selectable 100/120/220/240 VAC ± 10%.
- 48 to 66 Hz.
- 60 Volt-Amperes (maximum).

1.3.14 Environmental

0°C to 50°C (32°F to 122° F) operating; -40°C to 75°C (-6.2°F to 135°F) storage.

1.4 INSTRUMENT DESCRIPTION

The FIREBERD 1500A is designed to aid in troubleshooting and evaluating digital communications systems. With the appropriate interface module, the FIREBERD may be used to test communication systems configured as either data terminal equipment (DTE) or data communications equipment (DCE). The instrument has a fully independent transmitter and receiver to allow loop-around or end-to-end testing.

The FIREBERD 1500A measures bit error rate (BER), bit errors, block errors, blocks, errored seconds, error-free seconds, percent error-free seconds, and total seconds of test at any data rate between 50 Hz and 13 MHz. A six-digit display and a variety of front-panel indicators provide measurement results and the status of the system under test. Rear-panel test points allow data from the system under test to be further analyzed with an oscilloscope. Additional measurement features include: automatic data polarity detection, automatic synchronization, the ability to count through error bursts, and the ability to send and receive any of the standard pseudorandom patterns in a reverse or inverted format.

Extensive printout capability is provided. All available results may be printed out along with the elapsed time (time since power-up) and a label for each result. Data prints may be initiated manually or automatically. The front-panel controls allow automatic printing on time intervals, errors, or BER measurement cycles. Printouts are also provided on power-up, sync acquisition, sync loss, test restart, and various other important measurement events.

An RS-232 Printer Interface is provided as standard equipment. This interface may be used to provide data to TTC's PR-2000 Thermal Printer. An IEEE-488 Printer Interface is also available; this interface can be used to output directly to a 488-compatible printer. Alternatively, the IEEE-488 Interface and the RS-232 Interface allow the FIREBERD to operate in an Addressable Talker-Listener mode, in which the FIREBERD can output data and respond to several predetermined 488 bus or simple ASCII character commands.

Data and clock signals interface with the FIREBERD via plug-in modules which insert through the rear panel. Each interface module meets the appropriate standard interface specification and includes the standard connector. Many different interface modules are available; contact TTC for a current list.

Full self-test capability is provided. This feature allows all functions of the FIREBERD and interface module in use to be tested without any additional test equipment.

1.5 EQUIPMENT SUPPLIED

The following equipment is supplied with each unit:

FIREBERD 1500A (1500A-1)

a. Power Cord
b. Operating Manual
c. Protective Front Cover

FIREBERD MC1500A (MC1500A-1)

a. Power Cord
b. Operating Manual
c. Protective Front Cover

1.6 OPTIONS

The metal case option (described in Section 8.8) is obtained by ordering a FIREBERD MC1500A. All other options may be obtained by specifying the option number.

NOTE: Optional clock rates are not available in the 1500A-1 or MC1500A-1.

Option Number	Descriptions
001	IEEE-488 Interface (Addressable and Talker Only)
003	One Optional Clock Rate with 1ppm Accuracy
004	Two Optional Clock Rates with 1ppm Accuracy
005	Three Optional Clock Rates with 1ppm Accuracy
006	Four Optional Clock Rates with 1ppm Accuracy

Sections 6.5 and 8.10 provide additional information on these options.

1.7 ACCESSORIES

The following accessories are available from TTC for use with the FIREBERD 1500A. Detailed information on these accessories is provided in Sections 7 and 8.

Description	Model Number
RACK MOUNTS	
Rack Mount for FIREBERD 1500A and Printer	RM-1500A
Rack Mount for FIREBERD MC1500A and Printer	RM-MC
INTERFACE SWITCHING UNIT	ISU-2000
ISU Flush Door Accessory	10518
PRINTER	
Thermal Printer with Serial RS-232 Interface & Cable	PR-2000
Thermal Printer Paper (12 rolls)	10217-01

MISCELLANEOUS

Extra Manual	ML10278
Soft Carrying Case (for FIREBERD plastic & metal case)	10170
Hard Shipping Case (for FIREBERD plastic case)	10176
Hard Shipping Case (for FIREBERD metal case)	40527

INTERFACE MODULES

RS-232 Sync DTE/DCE	40236
RS-232 Sync/Isoch DTE	40232
RS-232/V.24/MIL-188C DTE/DCE Character (async)	40392
V.35/306 DTE/DCE	40202
RS-449 (422/423) DTE/DCE	40200
WECO 303 (cable included)	40182
T1 D4 (Framed/Unframed)	40405
T1 (Unframed) with APS	40365
CCITT G.703 64 kb/s Codirectional	40323
CCITT G.703 2.048 Mb/s	40380
CCITT G.703 8.448 Mb/s	30524
MIL-188C/MIL-188-114 Unbalanced	40226
MIL 188-114 Balanced	40298
LAB: Bal/Unbal, Polar/Bipolar (TTL Compatible)	40204
DS1C/DS2	30447
DS0/DS0A	30481

CABLES

RS-232/V.24 male-to-male (6')	10213
RS-232/V.24 male-to-male (10')	10418
V.35/306 34-pin male-to-male (6')	10214
V.35/306 34-pin male-to-male (10')	10419
RS-449/MIL-188 37-pin D, male-to-male (6')	10215
RS-449/MIL-188 37-pin D, male-to-male (10')	10417
WECO 310 plug to WECO 310 plug (10')[1]	10420
WECO 310 plug to alligator clips (10')[1]	10558
WECO 310 plug (dual) to 15-pin D adaptor (10')[2]	30375
WECO 310 plug to bantam plug (4')[1]	10599
WECO 310 plug to bantam plug (10')[1]	10559

WECO 310 plug (dual) to RJ48C (10')	40600
WECO 310 plug (dual) to RJ45C (10')	40511
MIL-188 male 37-pin D to male 25-pin D (6')[3]	10496
MIL-188 male 37-pin D to female 25-pin D (6')[3]	10538
Replacement Printer Cable (PR-2000)	30265
RS-449 DTE 37-pin D to X.21 DTE 15-pin D	10562
Bantam plug to bantam plug (10')	10615
Bantam plug to alligator slips (7')	10648
Bantam plug to 5-pin male Wescom adaptor (14')	30518
9-pin D male to 9-pin D male OIU adaptor (10')	20309

BREAKOUT BOXES

Breakout Box for RS-232C, V.24/V.28, MIL-188C	Model 25
Breakout Box for V.35, Bell 306	Model 34
Breakout Box for RS-449, V.10/V.11, MIL-188-114	Model 37

1.8 ORDERING INFORMATION

Equipment may be ordered by contacting:

Customer Service Department
TELECOMMUNICATIONS TECHNIQUES CORPORATION
444 North Frederick Avenue
Gaithersburg, MD 20877
Telephone: (301) 258-5011
Telex: 908736

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[1] For use with Model Nos. 40365 and 40405 T1 Interfaces, and Model No. 40380 CCITT G.703 Interface.

[2] For use with Model Nos. 40365 and 40405 T1 Interfaces.

[3] For use with Model No. 40226 Military Interface.

SECTION 2
PREPARATION FOR USE

2.1 INTRODUCTION

This section provides unpacking and initial inspection instructions, warnings, and power requirements.

2.2 UNPACKING AND INITIAL INSPECTION

The shipping container should be inspected for damage when it is received. If the shipping container or shipping material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. Procedures for checking electrical performance are given in Section 3. If the contents are incomplete, if there is mechanical damage or defect, or if the FIREBERD does not pass the performance tests, notify TTC. If the shipping container is damaged, notify the carrier as well as TTC, and keep the shipping container and materials for the carrier's inspection.

2.3 WARNINGS

The following precautions must be observed before and during all phases of operation of the instrument. Failure to comply with these precautions or specific warnings elsewhere in the manual may cause physical harm to the operator or to the instrument. TTC assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis must be connected to an electrical ground. The instrument is equipped with a three-conductor AC power cable. The

power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adaptor with grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet.

USE PROPER LINE VOLTAGE SETTING AND FUSE SIZE

Before connecting the AC power cord, verify that the line voltage selector card is positioned for the correct operating voltage. Never operate the instrument with the incorrect fuse size. See Section 2.4 for detailed information on setting the line voltage selection card and on proper fuse size.

KEEP AWAY FROM LIVE CIRCUITS

Do not remove instrument covers or insert fingers or other objects through rear-panel holes while power is applied to the instrument.

DO NOT SERVICE THE INSTRUMENT

Component replacement and internal adjustments must be made only by qualified maintenance personnel authorized by TTC.

TURN OFF POWER BEFORE INSERTING AND REMOVING INTERFACE MODULES

DO NOT OPERATE IN AN AMBIENT TEMPERATURE ABOVE 50° C

2.4 POWER REQUIREMENTS

The instrument requires a power source of 100, 120, 220, or 240 volts AC $\pm$ 10% single phase, 48 to 66 Hz that can deliver 60 volt amperes (maximum). The instrument is normally shipped from the factory set to operate from a 120-volt power source. To operate the instrument from a different source voltage, proceed as follows:

1. Remove the input power cord.
2. Slide the plastic door to the left.
3. Remove the fuse.
4. Pull the voltage select card straight out.
5. Change the orientation of the voltage select card and reinsert so the appropriate operating voltage is visible on the card after it has been installed.
6. Install the appropriate size fuse (see Table 2-1).
7. Slide the plastic door to the right and reinsert power cord.

Table 2-1
Fuse Size

Operating Voltage	Fuse Size	Fuse Type
100	1/2 amp 250V	3AG
120	1/2 amp 250V	3AG
220	1/4 amp 250V	3AG
240	1/4 amp 250V	3AG

SECTION 3
INSTRUMENT CHECKOUT

3.1 INTRODUCTION

This section describes the automatic self-test that the FIREBERD performs at power-up. Also included is a manual self-test which can be used to verify proper operation of the FIREBERD. The following procedures assume that the user is familiar with the controls and operation of the FIREBERD; unfamiliar users should review Sections 4, 5, and 6.

3.2 AUTOMATIC SELF-TEST

The automatic self-test is performed each time the FIREBERD 1500A is powered up. The unit performs an internal check of ROM, RAM, some switch positions, and a loop test on the RS-232 printer port. In addition, all of the displays and indicators are briefly illuminated to verify proper operation. All tests are completed within 2 seconds. If no failures are detected, the FIREBERD will operate normally after the test. If a failure does occur, the FIREBERD will display an error message (ERROR X) and print out the words SELF TEST FAIL. If the FIREBERD fails to operate properly, TTC should be contacted for service.

3.3 MANUAL SELF-TEST

The manual self-test is performed with the TEST switch in the LOOP position. The FIREBERD's operation in this mode is directly related to the interface selected. If the interface module is suspected of failing during the manual self-test, insert another interface module and repeat the test. Remember that power to the FIREBERD must be turned OFF before inserting or removing an interface.

Although any interface module may be used for this procedure, the interface module switches must be appropriately set (see Table 3-1) and an appropriate generator clock source must be selected for the module used (see Table 3-2). If the interface module has

Table 3-1

Interface Switch Settings For Loop Testing

INTERFACE MODULE	SWITCH POSITION
RS-232 DTE (40112)	RCV CLK "NORMAL" — TX CLK "NORMAL"
RS-232 Isoch/Sync DTE (40232)	BAUD RATE —1 — TIMING "INT" or "BAUD RATE"
RS-232 Async Character DTE/DCE (40392)	BAUD RATE —1 — UPPER/LOWER —1 — PARITY —1 — STOP BITS —1 — BIT ORDER —1 — 188C/NORM "NORM"
RS-232 DTE/DCE (40236)	DTE-TX CLK "NORMAL" — DTE-RCV CLK "NORMAL" — DTE/DCE "DTE"
RS-449 (422/423) DTE (40263)	423/422 UNTERM/422 TERM "422 TERM" — TX CLK "NORMAL" — RCV CLK "NORMAL"
RS-449 (422/423) DTE/DCE (40200)	423/422 UNTERM/422 TERM "422 TERM" — (TX) RCV "NORM" — DCE/DTE "DTE" — (RCV) TX "NORM"
T1 (40365)	MODE "NORMAL" — APS TEST —1 — TX TIMING "XTAL" — BRIDGE/TERM "TERM"
WECO 303 (40182)	RCV CLK "NORMAL" — TX CLK "NORMAL"
LAB (40204)	MODE "UNIPOLAR BAL" — INPUT IMPED —1 — CLK PHASING —1
MIL 188-114 Balanced (40298)	DATA RATE —1 — DECADE MULT —1 — TERM —1 — MODE "SYNC"
MIL 188C/MIL 188-114 Unbalanced (40226)	DATA RATE —1 — DECADE MULT —1 — IF TYPE "114 UNBAL" — MODE "SYNC"
64 Kbps G.703 (40323)	OCTET TIMING —1
2.048 Mbps G.703 (40380)	TIMING "XTAL" — CODE "AMI" — MODE "NORM" — IMPED "TERM"
V.35/306 DTE (40138)	TX CLK "NORMAL" — RCV CLK "NORMAL"
V.35/306 DTE/DCE (40202)	TIMING MODE —1 — DTE-TX CLK "NORMAL" — DTE RCV CLK "NORMAL"
DS1/T1 (D4 Framing) (40405)	MODE "NORM" — CODE —1 — TIMING "XTAL" — IMPEDANCE "TERM" — QRSS —1 — DATA "UNFRAMED"

1) NOTE: —— Set to any position

Table 3-2

GENERATOR CLOCK Switch Settings For Loop Testing

Interface Module	Switch Position
RS-232 DTE (40112)	1.2, 2.4, 4.8, 9.6, 19.2, FA[1]
RS-232 Isochronous/Synchronous DTE (40232)	1.2, 2.4, 4.8, 9.6, 19.2, FA[1]
RS-232 Character DTE/DCE (40392)	EXT
RS-232 DTE/DCE (40236)	1.2, 2.4, 4.8, 9.6, 19.2, FA[1]
RS-449 (422/423) DTE (40263)	1.2, 2.4, 4.8, 9.6, 19.2, 56, 64, FA[2]
RS-449 (422/423) DTE/DCE (40200)	1.2, 2.4, 4.8, 9.6, 19.2, 56, 64, FA[2]
T1 (40365)	FA[3], EXT
WECO 303 (40182)	1.2, 2.4, 4.8, 9.6, 19.2, 56, 64, FA[4]
LAB (40204)	1.2, 2.4, 4.8, 9.6, 19.2, 56, 64, FA[2]
MIL 188-114 Balanced (40298)	1.2, 2.4, 4.8, 9.6, 19.2, 56, 64, FA[2]
MIL 188C/MIL 188-114 Unbalanced (40226)	1.2, 2.4, 4.8, 9.6, 19.2, 56, 64, FA[4]
64 kb/s G.703 (40323)	64, FA[5], EXT
2.048 Mb/s G.703 (40380)	FA[6], EXT
V.35/306 DTE (40138)	1.2, 2.4, 4.8, 9.6, 19.2, 56, 64, FA[2]
V.35/306 DTE/DCE (40202)	1.2, 2.4, 4.8, 9.6, 19.2, 56, 64, FA[2]
DS1/T1 (D4 Framing) (40405)	EXT
8.448 Mb/s G.703 (30524)	FA[7], EXT
DS1C/DS2 (30447)	FA[8], EXT
DS0/DS0A (30481)	EXT[9]

NOTES:

1. Use only if optional clock with frequency below 20 kHz is provided.
2. Use only if an optional clock is provided.
3. Use only if 1.544 Mb/s clock is provided.
4. Use only if optional clock with frequency below 100 kHz is provided.
5. Use only if 64 kb/s clock is provided.
6. Use only if 2.048 Mb/s clock is provided.
7. Use only if 8.448 Mb/s clock is provided.
8. Use only if 3.152 Mb/s or 6/312 Mb/s clock is provided.
9. Timing source is required for the Loop Testing.

clock invert switches, they should be placed in the NORMAL position. Other interface module switches should be set appropriately. Refer to Section 7 for information on interface switch settings; if an interface is not included in Section 7, refer to the individual operating manual. If servicing is required, it is helpful to the areas of the test in which the FIREBERD failed.

3.4 PREPARATION

(1) Install the interface module with the AC power off.

(2) Verify that the AC line-voltage card is set appropriately for the existing line voltage. Turn on the (PWR) power switch.

(3) The TEST switch must be in the LOOP position throughout the entire test unless otherwise specified.

(4) Set the MODE switch to SINGLE ERROR MODE.

(5) Set the interface switches according to Table 3-1.

3.4.1 Generator Clock

(1) Set the GENERATOR CLOCK switch to the desired frequency (refer to Table 3-2).

(2) Ensure that the GENERATOR CLOCK is set at an available clock frequency. If the GENERATOR CLOCK switch is set to an EXT position, the clock signal used for the test must be input through the interface module or through the BNC (EXT CLK IN) on the rear panel of the FIREBERD.

NOTE: The FA, FB, FC, and FD positions must have the appropriate oscillator option installed (1500A only).

(3) The GEN CLK and RCV CLOCK/TX CLOCK activity indicators should be illuminated.

3.4.2 Data

(1) Set the GENERATOR CLOCK switch to the desired frequency (refer to Table 3-2).

(2) Note that there must be generator clock activity to develop transmit clock and data.

(3) Set the TEST switch to the LOOP position and ensure that the interface module is installed and set appropriately.

(4) Set the PATTERN switch to the 2047 position.

(5) Set the ERROR INSERT switch to the OFF position.

(6) Set the DATA switch to the NORM position.

(7) Verify that the RCV MARK/TX MARK and RCV SPACE/TX SPACE indicators are illuminated and that RCV DATA INV/TX DATA INV indicators are off.

(8) Set the PATTERN switch to the MK (Mark) position.

(9) Verify that the RCV MARK/TX MARK indicator is illuminated and that the RCV SPACE/TX SPACE indicator is off.

3.4.3 Synchronization and Error Count

(1) Set the GENERATOR CLOCK switch to the desired frequency (refer to Table 3-2).

NOTE: Be sure that the generator clock is active and that you are not exceeding the maximum data rate inherent to the particular interface module in use:

V.35 - 13 MHz
RS-232 - 20 kHz
*499 - 423 - 20 kHz or 112 kHz
449 - 422 - 10 MHz
LAB - 13 MHz
WECO 303 - 500 kHz

*112 kHz maximum RS-423 mode operation for Models 40180 and 40263 RS-449 DTE Interface Modules and Model 40200-01 RS-449 DTE/DCE Interface Module, 20 kHz for Model 40200-02 RS-449 DTE/DCE Interface Modules.

(2) Set the PATTERN switch to the 2^{20}-1 position.

(3) Set the ERROR INSERT switch to the OFF position.

(4) Set the MODE switch to the SINGLE ERROR MODE position.

(5) Set the DATA switch to the NORM position.

(6) Set the AUTO SYNC switch to the the ENABLE position.

(7) Set the RESULT HOLD/UPDATE/RESET to the UPDATE position.

(8) Set the TEST switch to the LOOP position.

(9) Set the AUDIO switch to the LOW position.

(10) Press RESET.

(11) The FIREBERD should now be synchronized with the incoming data. The SYNC indicator should be illuminated and the SYNC LOST and RCV DATA INV indicators should be off.

NOTE: There must be a receive clock and data signal for synchronization to occur.

(12) Select each DISPLAY SELECT switch position and verify that the following results are displayed:

1. ERRORS - Zero
2. ERR SEC - Zero
3. SEC - Counting

(13) Press the ERROR INSERT switch 10 times.

(14) Verify that 10 errors as well as several errored seconds are displayed.

(15) Set the ERROR INSERT switch to the 10^{-3} position, set the MODE switch to the AUTO BER position, and press the RESET switch.

(16) Within 84 seconds of the Test Restart, verify that the BER display reads 1.00E-3 and that the Audio Indicator beeps.

NOTE: At the other operating frequencies or test lengths, the results may take either a shorter or longer time to appear. The BER mode update is dependent on the clock rate and the BER test length.

$$\text{BER update time in seconds} = \frac{\text{test length (bits)}}{\text{clock frequency (bits/secs)}}$$

3.4.4 Printer

To test FIREBERD operation with the PR-2000 Thermal Printer, use the following procedure.

(1) Securely connect the special cable provided between the PR2000 printer and the RS-232C PRINTER connector on the rear panel of the FIREBERD.

NOTE: The FIREBERD's connector pin assignments are given in Section 6.4.3.

(2) Verify that the printer paper is properly loaded with paper and is turned on.

(3) The RS-232 DATA FORMAT switch should be set with all of its switches in the up position for normal operation with a PR-2000 printer (see Section 4.2.6).

(4) Set the PRINT CONTROL switch to the DISABLE position.

NOTE: All printer functions are disabled in the PRINT CONTROL DISABLE position.

(5) Set the GENERATOR CLOCK switch to the 19.2 position.

(6) Set the MODE switch to the SINGLE ERROR MODE position.

(7) Set the TEST switch to the LOOP position.

(8) Set the PRINT CONTROL (EVENT) switch to the 30 position.

(9) Set the PRINT CONTROL switch to the AUTO position.

(10) Press the RESET switch.

(11) Verify that a TEST RESTART message is printed.

(12) Set the PRINT CONTROL EVENT switch to the ERR position and insert a single error. Then press the PRINT switch.

(13) Verify that two sets of data results are printed.

SECTION 4
INSTRUMENT DESCRIPTION

4.1 INTRODUCTION

This section describes the FIREBERD 1500A's front-panel controls, indicators connectors, and test points. This section concludes with a functional description for each of the major elements which make up the instrument.

4.2 CONTROLS AND INDICATORS

Figure 4-1 shows the FIREBERD 1500A front panel. The numbers for each item in the figure correspond to the numbered descriptions in the following sections.

It is important to note that the movement of some switches on the FIREBERD will restart a test. Other switches may be changed without affecting the ongoing test, while some switch changes may cause a loss of synchronization by interrupting the clock or data signals.

- Switches that cause a test restart:
  - MODE (BER/SINGLE ERROR/BLOCK)
  - RESET
  - PWR
  - Interface Module switches on some interfaces.

- Switches which will not cause a test restart or loss of synchronization:
  - ERROR INSERT
  - DISPLAY SELECT
  - AUTO SYNC[1]

[1] If an error rate of 10^{-1} or greater occurred in the DISABLE position, switching to the ENABLE position will cause a loss of synchronization and test restart.

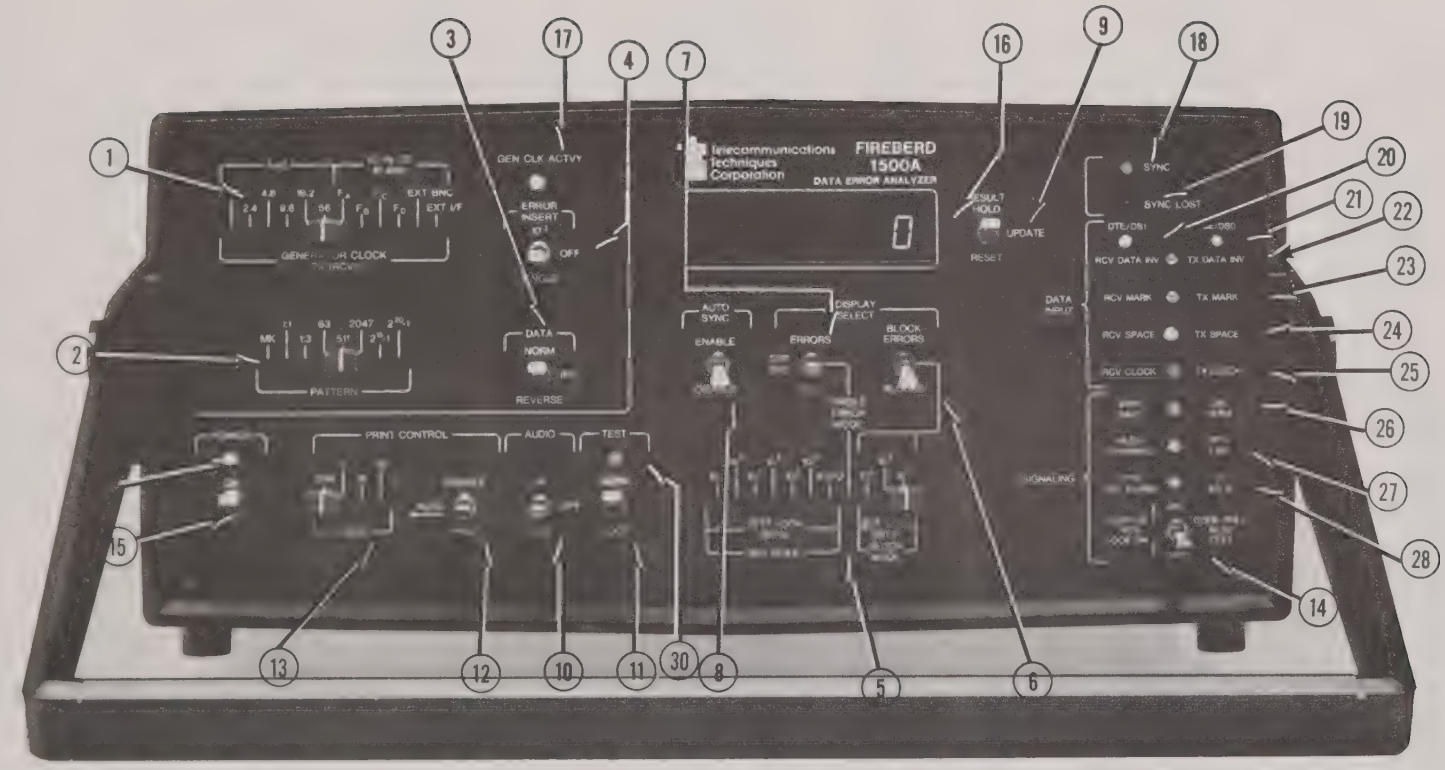

Figure 4-1
FIREBERD 1500A FRONT PANEL

RESULT HOLD/UPDATE/RESET (except the RESET position)
RTS/RLSD
AUDIO
PRINT CONTROLS

- Switches which may cause a loss of synchronization:
  GENERATOR CLOCK
  PATTERN
  TEST
  DATA
  Some interface switches

4.2.1 Controls

Listed below are descriptions of the FIREBERD 1500A front-panel controls. The numbers preceding each description correspond to the numbers in Figure 4-1.

1. GENERATOR CLOCK TX (RCV)

This slide switch selects the generator clock from one of six standard internal frequencies (1.2, 2.4, 4.8, 9.6, 19.2, and 56 kHz), one of four optional user selectable internal frequencies (FA, FB, FC, and FD), the external input from the rear-panel BNC connector (EXT BNC), or the external input on the plug-in interface module (EXT I/F).

NOTE: For the FIREBERD 1500A-1 this switch selects the generator clock from one of 9 standard internal frequencies (1.2, 2.4, 4.8, 9.6, 19.2, 56, 60, 64, and 72 kHz), the external input from the rear panel BNC connector (EXT BNC), or the external input on the plug-in interface module (EXT I/F).

2. PATTERN

This PATTERN slide switch selects the generator and receiver test patterns from: constant Mark (MK), alternating Mark - Space (1:1), Mark followed by 3 Spaces (1:3), or one of five pseudorandom patterns (63, 511, 2047, 2^{15}-1, 2^{20}-1).

3. DATA

The DATA toggle switch selects the generator and receiver test patterns to be either normal (NORM), inverted (INV) or reverse (REVERSE). The REVERSE position reverses the bit sequence of the selected pattern. Reverse pseudorandom patterns have the same statistical properties as the corresponding forward (normal) patterns. The REVERSE position is used primarily to allow operation with test sets produced by other manufacturers which provide reverse sequences.

4. ERROR INSERT

The ERROR INSERT toggle switch causes errors to be placed in the generator data stream. When this switch is toggled to the SINGLE position, a single error is inserted. When the switch is in the OFF position, no errors are inserted. When the switch is toggled to the 10^{-3} position a continuous error rate of 1 error per 1000 bits is inserted into the generated data stream.

5. BER MODE

The BER MODE slide switch selects one of the three operating modes for the test set. The left-most six positions of this switch are used for fixed length BER measurements. The numbers above the switch indicate the number of bits used to compute the BER result. For example, in the 10^7 position, errors are accumulated over a period of 10^7 bits and the number of errors is divided by 10^7 to get the BER result.

The AUTO position performs a BER test which starts by counting errors over a 10^5 bit interval. After 10^5 bits, a BER result will be available for display or printout and the test will be restarted at this point if 100 or more errors have been accumulated. The BER test will continue if less than 100 errors have been counted. If 100 or more errors have been counted when 10^6 bits have been received the new result will be available for display or printout. If less than 100 errors are present, the measurement will continue until 10^7 bits have been received. In this manner, the BER test will continue until a result with at least 100 errors is available or until a 10^{10} bit test length is reached. In either case, the result will be output and the test will be restarted. The last complete result obtained (a

result with more than 99 errors or a result for a 10^{10} bit interval) will be used for display and print out until the next result with more than 100 errors or 10^{10} bits is obtained.

In the SINGLE ERROR MODE position, errors, errored seconds, and total seconds of the test are continuously accumulated. The DISPLAY SELECT (ERRORS/ERR SEC/SEC) switch determines which result is displayed.

In the BLOCK MODE positions (three right-most switch positions), blocks and block errors are continuously accumulated. The number above each switch position (10^3, 10^4, or 10^5) represents the block length in bits. The BLOCK ERRORS/BLOCKS switch position determines which result is displayed.

6. DISPLAY SELECT

This toggle switch selects the block errors or blocks result to be displayed in Block Errors mode.

7. DISPLAY SELECT

In SINGLE ERROR MODE, this toggle display select switch selects the result to be displayed. In BER or Block Mode, this switch will cause the display to show the total seconds of testing for three seconds when toggled into the SEC position.

8. AUTO SYNC

When synchronization is initiated, the automatic-synchronization circuitry will attempt to synchronize to the incoming data. Once synchronization has been acquired, the position of the AUTO SYNC switch determines how the test set will respond to very high error rates.

In the ENABLE position, the receiver will automatically resynchronize and restart the test if 100 or more errors occur in a 1000 bit interval (10^{-1} error rate).

In the DISABLE position, the receiver is inhibited from resynchronizing at any error rate. This allows the unit to perform measurements on channels with high error rates which would normally cause the unit to resynchronize and restart the test.

The ENABLE position should be used unless error bursts or error rates greater than 10^{-1} are anticipated. The AUTO SYNC switch may be changed from the ENABLE to the DISABLE position during a test without causing a test restart. When this switch is changed from DISABLE to ENABLE, the test will not restart unless the error rate exceeds 10^{-1}.

9. RESULT HOLD/UPDATE/RESET

Toggling this switch to the RESET position will clear all of the result accumulators, restart the test, and force a resynchronization to the incoming data.

The UPDATE position allows the display to change as the ongoing tests dictate. This is the normal operating position for the FIREBERD test set.

The RESULT HOLD position will freeze the result currently being displayed as well as all other results selectable via the DISPLAY SELECT switches.

10. AUDIO

The AUDIO toggle switch sets the internal Audio Indicator to HIGH volume, OFF, or LOW volume. The indicator will beep once at the end of each BER measurement cycle and twice on the occurrence of a sync loss. In Single Error or Block Mode, the indicator will beep on the occurrence of an error or block error.

11. TEST

The TEST toggle switch selects normal operation in the NORM (normal) position. The LOOP position activates a relay or data selector on the interface module which loops the transmit clock and data outputs back to the receive clock and data inputs. The relay or data selector also isolates the interface connector so that the interface cable need not be removed for the loop test.

12. PRINT CONTROL

The DISABLE position inhibits data output from either the RS-232 or IEEE-488 printer interfaces and also clears the internal printer buffer (FIFO) at the end of the present result print.

In the AUTO position, data will be provided to the printer: (1) upon the acquisition of or loss of receiver synchronization in any operating mode; (2) at the end of the measurement cycle in BER Mode; or (3) according to the setting of the EVENT switch in the Single Error or Block Mode.

When the PRINT CONTROL switch is toggled to the the PRINT position, an immediate printout of all present results occurs.

13. PRINT CONTROL (EVENT)

In the Single Error or Block Mode, the ERR (Error) position causes a printout to be initiated on the occurrence of an errored second and every 60 minutes. The 1, 10, and 30 positions initiate printouts every 1, 10, and 30 minutes.

14. RTS/RLSD

Controls the state of the RTS (Request to Send) signaling leads output when the FIREBERD is used as a DTE with V.35/306, RS-232, RS-449, or WECO 303-type Interface Modules. For DCE operation, this switch controls the Receiver Ready (RR) signaling lead for the RS-449 DTE/DCE Interface Module and RLSD (Receive Line Signal Detect) lead for V.35/306 DTE/DCE or RS-232 DTE/DCE Interface Modules.

15. PWR

Applies power to, or removes power from, the instrument.

4.2.2 Front-Panel Indicators

The following are descriptions of the FIREBERD 1500A front-panel indicators. The numbers preceding each description correspond to the numbers in Figure 4-1.

16. 6-DIGIT DISPLAY

Displays error-analysis test results. Errors, errored seconds, seconds, blocks, and block errors are all displayed in 6-digit format with no decimal point or exponent.

BER is displayed in the format X.XXE-X. For measurement results with more than 99 errors, the display format will be scientific notation; for example, 1.03E-6. If the result has more than 9 but less than 100 errors, the result will be displayed with a 2-digit mantissa; for example, .99E-6. If the result has less than 10 errors, a 1-digit mantissa is provided; for example, .09E-6. The intent of this method of display format is to warn the operator that the result may not contain enough errors to be statistically reliable.

Three decimal points are illuminated and the display flashes when the result being displayed has overflowed.

17. GEN CLK ACTVY

The GEN CLK ACTVY indicator shows that a clock is present at the pattern-generator input (transmit clock for DTE operation or receive clock for DCE operation).

18. SYNC

Indicates that the receiver is synchronized to the incoming data. Must be illuminated for any error-analysis test to proceed.

NOTE: Once synchronization is obtained, loss of synchronization will not be detected in Auto Sync Disable mode.

19. SYNC LOST

In Auto Sync Enable mode, this indicator will illuminate when synchronization has been lost at least once since the test started. Once illuminated, this indicator will only be reset by starting a new test via the RESET switch, or by changing one of the test parameters which causes a test restart.

In Auto Sync Disable mode, this indicator will flash at a (2Hz) rate for 5 seconds then return to its previous state if the error rate has exceeded 10^{-1} over the last 1000 bit interval.

20. DTE/DS1

Illuminates when the FIREBERD is acting as data terminal equipment (DTE).

21. DCE/DS0

Illuminates when the FIREBERD is acting as data communications equipment (DCE).

22. RCV DATA INV/TX DATA INV

Illuminates in DTE operation when the received data is inverted or in DCE operation when the data being received by the FIREBERD error-analysis circuitry (TX DATA) is inverted. This indicator is not applicable when the SYNC indicator is off.

23. RCV MARK/TX MARK

Illuminates each time a Mark is detected in the receive or transmit data for DTE or DCE operation.

24. RCV SPACE/TX SPACE

Illuminates each time a Space is detected in receive or transmit data for DTE or DCE operation.

25. RCV CLOCK/TX CLOCK

For DTE operation, this indicator illuminates when receive clock activity exists at the input to the error-analysis circuitry. For DCE operation, this indicator illuminates when there is transmit clock activity at the input to the error-analysis circuitry.

26. DSR/DIR TERM

For DTE operation, this indicator illuminates when the Data Set Ready signaling lead is in the ON condition for the RS-232, WECO 303, and V.35/306-type Interface Modules; or when the Data mode signaling lead is in the ON condition for RS-449-type Interface Modules. In DCE operation, this indicator illuminates when Data Terminal Ready is in the ON condition.

27. RLSD FRAMING/RTS LBA

When the FIREBERD is acting as a DTE, this indicator illuminates when the Receive Line Signal Detector is in the ON condition for the RS-232, WECO 303, or V.35/306-type Interface Modules, or when the Receiver Ready is ON for the RS-449-type Interface Modules.

When the FIREBERD is acting as a DCE, this indicator will illuminate when the Request to Send signaling input is in the ON condition for RS-232, RS-449, and V.35-type Interface Modules.

28. CTS YEL ALARM/LT BIT 8

Illuminates when the Clear to Send signaling lead is in the ON condition during DTE operation for all FIREBERD Interface Modules which support CTS. When the FIREBERD is acting as a DCE, this indicator illuminates when the Local Loopback input is in the ON condition for the RS-449 DTE/DCE Interface Module.

29. PWR

Illuminates when the FIREBERD has power applied.

30. TEST

Flashes when the FIREBERD is in Loopback (LOOP) mode.

4.2.3 Connectors

Listed below are descriptions of the FIREBERD 1500A rear-panel connectors. The numbers preceding each description correspond to the numbers in Figure 4-2.

33. EXT CLK IN

Used to input signals ranging from 1 volt to 25 volts peak-to-peak for use as the generator clock when the GENERATOR CLOCK switch is in the EXT BNC position.

34. RS-232 PRINTER

Used to interface with a RS-232 printer.

35. AC INPUT

Power input from AC line.

36. VOLTAGE SELECT 100/120/220/240

Used to select the AC operating voltage. Voltage setting may be changed by: (1) removing the power cord, (2) sliding the plastic door to the left, (3) removing the fuse and, finally, (4) removing the selector card. Once removed, the card may be reinserted to select a different operating voltage range. The operating voltage selected is visible through the plastic door once the card is installed (see Section 2.4).

37. GROUND STUD

Connected to chassis and circuit ground.

51. IEEE-488 INTERFACE CONNECTOR

Connector for the IEEE-488 Option.

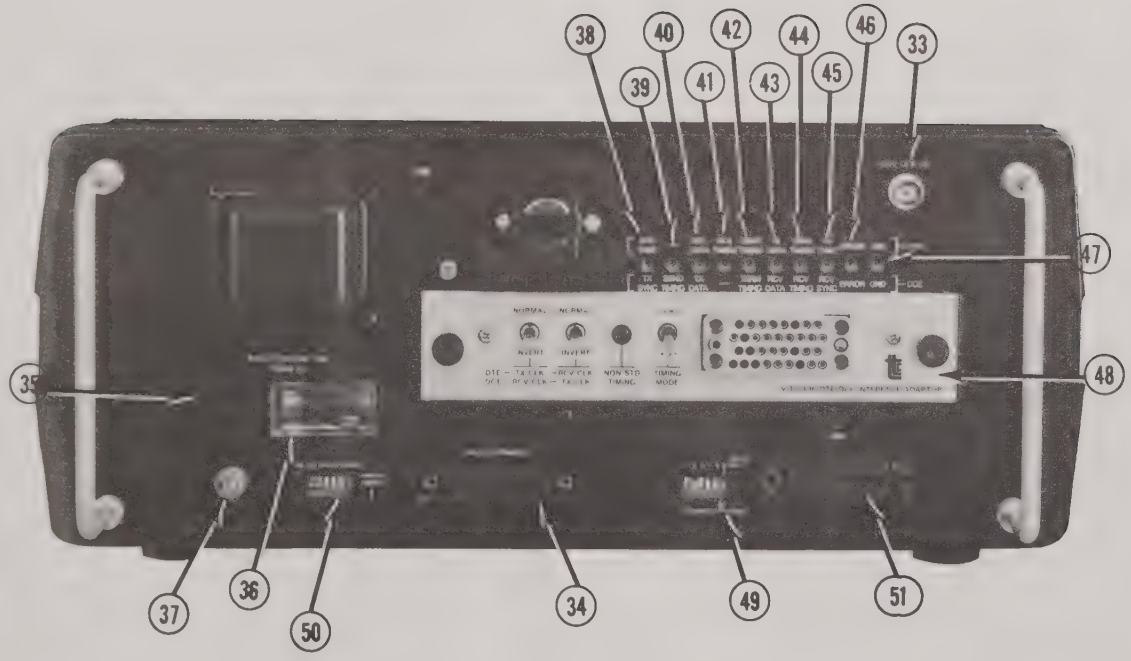

Figure 4-2
FIREBERD 1500A REAR PANEL

4.2.4 Test Points

Listed below are descriptions of the FIREBERD 1500A rear-panel connectors. The numbers preceding each description correspond to the numbers in Figure 4-2.

All test points except ground (GRD) are driven by standard TTL gates with 2K ohm pull-up resistors.

In the descriptions which follow, test points which have different names for DTE and DCE operation have a "/" separating the two names. The names on the left and right are applicable for DTE and DCE operation. A "-" indicates that the test point is not applicable for the particular operating mode.

38. RCV SYNC/TX SYNC

This test point provides one pulse for each repetition of the incoming pseudorandom pattern.

39. -/SEND TIMING

For DCE operation this test point develops a signal equivalent to that being transmitted at the Send Timing (ST) or TX Clock DCE source interface output lead. This test point is not applicable in DTE operation.

40. RCV DATA/TX DATA

This test point develops a signal equivalent to the signal at the incoming data input to the error-analysis circuitry of the FIREBERD.

41. RCV TIMING/-

For DTE operation the receive-timing test point provides a TTL signal equivalent to the received clock at the input to the interface. This test point is not applicable for DCE operation.

42. SEND TIMING/TERM TIMING

Outputs a TTL signal equivalent to the clock signal at the interface connector. Note that send timing is equivalent to Tx Clock DCE source and term timing is equivalent to TX Clock DTE source.

43. TX DATA/RCV DATA

This test point provides a TTL equivalent to the data signal output from the interface.

44. TERM TIMING/RCV TIMING

This test point provides a TTL equivalent of the generator clock at the output of the interface.

45. TX SYNC/RCV SYNC

This test point provides one pulse for each repetition of the selected pseudorandom pattern generated by the FIREBERD.

46. ERROR

For DTE or DCE operation this test point pulses high once for each error detected by the FIREBERD error-analysis circuitry.

47. GND

Provides a circuit and chassis ground reference.

4.2.5 Interface Module Components (LAB Interface)

The following are descriptions of the FIREBERD 1500A rear-panel connectors. The numbers preceding each description correspond to the numbers in Figure 4-2.

48. Refer to appropriate interface in Section 7.

4.2.6 Rear-Panel Switches

Listed below are descriptions of the FIREBERD 1500A rear-panel connectors. The numbers preceding each description correspond to the numbers in Figure 4-2.

49. IEEE-488 Interface Control Switch

This switch controls the operation of the IEEE-488 Interface when option 001 is installed. The right-most switch selects Talk Only mode in the up position or Addressable mode in the down position. The five left-most switches select the address for Addressable mode. Each switch sets the corresponding binary-address bit to a one or zero for the up or down position. This switch is read only on power-up.

50. RS-232 DATA FORMAT

Sets the printer format. If the TTC PR-2000 Thermal Printer is used, all switches should be up. For printers other than the PR-2000, refer to Table 4-1. This switch is read only on power-up.

4.3 INTERNAL DESCRIPTION

4.3.1 General

The FIREBERD can be functionally divided into six sections: transmitter, interface module, receiver, processor, control panel, and power supply. Figure 4-3 is a block diagram for the FIREBERD. Refer to this diagram for the following description.

The transmitter generates the test pattern to be used for the error-analysis measurements. The transmit side of the interface module provides a signal conversion from the TTL characteristics provided by the transmitter to the characteristics

Table 4-1

RS-232 Data Format

Switch #	Function	Result
1, 2	Baud Rate Control	00 = 300 01 = 600 10 = 1200 11 = 2400
3	Stop Bits	1 = 2 bits, 0 = 1 bit
4	Print Speed	1 = FAST, 0 = SLOW
5	Parity	1 = EVEN, 0 = ODD
6	LF After CR	1 = NO, 0 = YES

0 = DOWN 1 = UP

NOTE: These switches are read only on power-up.

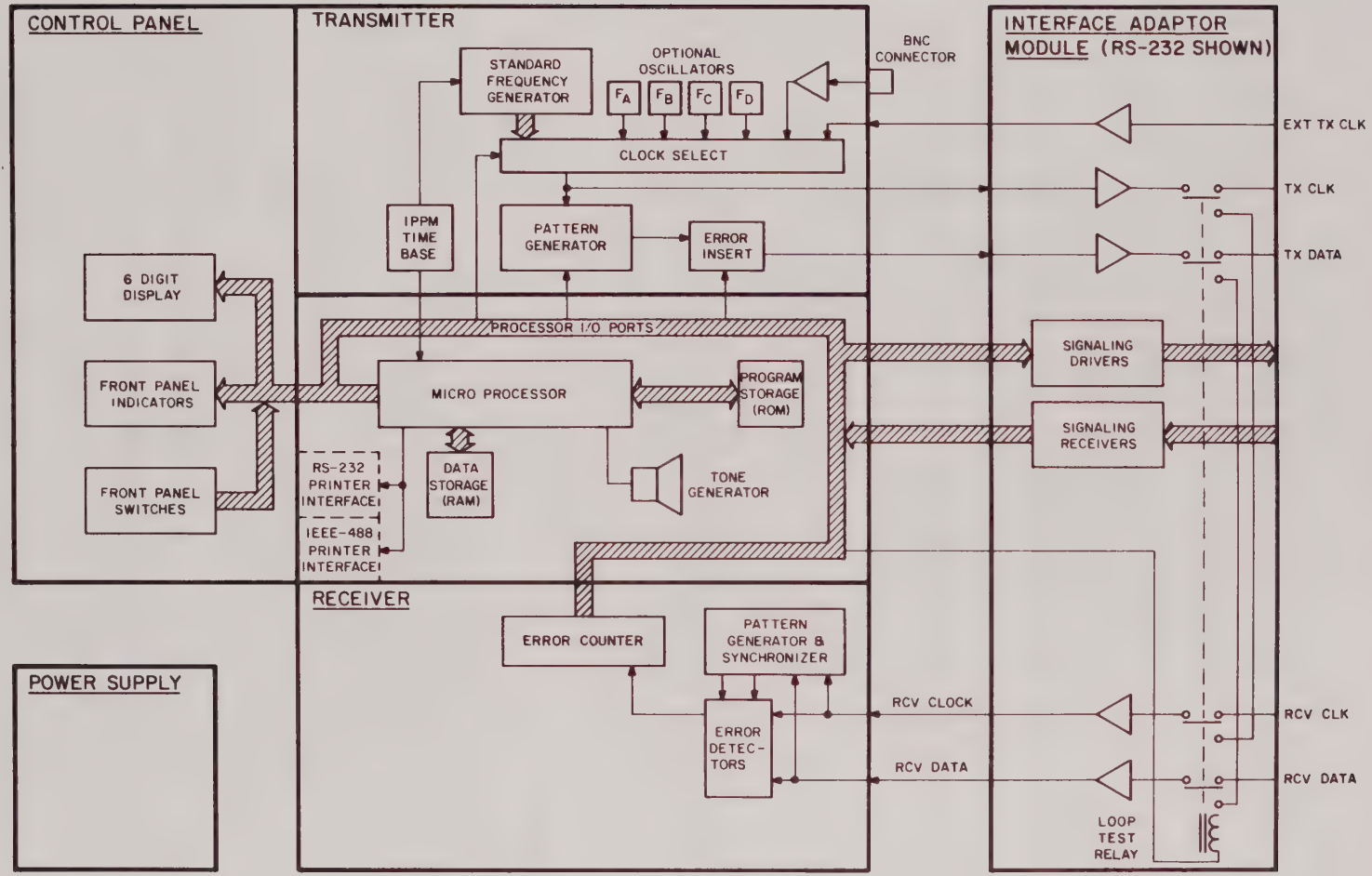

FIGURE 4-3
FIREBERD 1500A BLOCK DIAGRAM

appropriate for the interface standard in use. The output of the interface module drives the system under test. The test pattern passes through the system under test and is received by another FIREBERD, or is looped back to the same FIREBERD which originated it. In either case, the receive portion of the interface module converts the received pattern into a TTL signal and passes it on to the receiver.

The receiver synchronizes a pattern generator identical to the one in the transmitter with the incoming data stream. The output of this pattern generator is compared with the incoming data and an error pulse is generated for each discrepancy between the transmitted and received data.

The processor serves as a controller and computer for the instrument. It inputs control setting information from the control panel, timebase, and status information from the transmitter, interface type from the interface module, and result counts from the receiver. Results and system status information are computed and output to the display and indicators, printer interfaces, and the tone generator.

4.3.2 Transmitter

The transmitter generates the digital test pattern using a 20-stage shift register with adjustable feedback taps to an exclusive-OR gate feeding the shift-register input. The configuration of this shift register is set by a front-panel switch to provide 63, 511, 2047, 2^{15} -1, or 2^{20} -1 pseudorandom patterns. Alternatively, a Mark, 1:1, or 1:3 (one Mark followed by three Spaces) pattern may be selected.

Each of the pseudorandom data patterns supplied by the FIREBERD 1500A may be transmitted in its reverse sequence by setting the DATA switch to the REVERSE position. Also any normal data pattern selected by the PATTERN switch may be inverted by placing the DATA switch into the INVERT position.

A timebase with a 1 ppm accuracy provides timing to the processor and standard frequency generator. The GENERATOR CLOCK switch is used to select: one of the

standard internal rates, one of the four optional oscillators (1500A)[1], the external clock from the BNC receiver, or the external clock from the interface module. The selected clock is used to drive the pattern generator and is sent back to the interface module.

Error-insert circuitry is provided between the pattern generator and the interface module's data input. Each time the ERROR INSERT switch is toggled to the SINGLE position, one bit in the transmitted data stream is inverted. When the switch is placed in the 10^{-3} position, 1 bit in every 1000 bits is inverted.

A transmit-pattern sync output on the rear panel provides one pulse for every repetition of the selected pseudorandom pattern. This output may be used to synchronize an oscilloscope to the pseudorandom pattern while tracing the test pattern through a system or looking for the presence of errors.

The transmit data and clock are passed from the error-insert and clock-select circuitry to the interface module which provides the electrical characteristics appropriate to drive the system under test.

4.3.3 Interface Module

The interface module shown in Figure 4-3 and described here is a RS-232 synchronous type. Other interface modules are described in Sections 5.4, 5.5, and 7.0.

The transmit section of the interface module contains a line receiver which receives an external clock (if one is in use) and directs it to the FIREBERD's transmitter clock-select circuitry. It also provides line drivers for the transmit clock, transmit data, request to send, and data terminal-ready outputs.

[1] Optional oscillator positions are not available on the 1500A-1.

The receive section of the interface module provides line receivers for the receive clock, receive data, clear to send, data set ready, and receive line signal detect. The received clock and data signals are passed to the receiver for error analysis and the signaling status is sent directly to the front panel for display.

The interface module also provides clock-invert switches (not shown) for both the transmit and receive clocks. When the TX CLK (transmit clock) switch is in the NORM position, the phasing between the transmit clock and data is as specified by the interface specification. In the INVERT position, the phasing is opposite to that specified by the interface specification. The RCV CLK (receive clock) switch works in the same manner for the phasing between the receive clock and data. A red indicator illuminates to warn the operator of non-standard timing when either of the switches is taken out of the NORM position.

A relay is provided for loop testing on some interface modules. When the TEST switch on the FIREBERD front panel is placed in the LOOP position, the interface module loops the transmit clock and data outputs back to the receive clock and data inputs. The relay also disconnects these same lines from the interface connector so that the interface cable does not need to be disconnected for the test. This loop-test feature allows the operator to insert errors with the ERROR INSERT switch and verify the proper operation of both the FIREBERD and the interface module.

4.3.4 Receiver

The interface module provides receive data and clock signals at TTL levels to drive FIREBERD's receiver.

On test initialization the pattern generator in the receiver (similar to the one in the transmitter) automatically attempts to synchronize itself to the incoming data. Once synchronization has occurred, the error detector compares the incoming data with the internally generated pattern and counts discrepancies as errors. If the incoming data is inverted, the unit will automatically correct the inversion, attempt synchronization, and illuminate a front-panel indicator. This allows the measurement to be performed and warns the operator of the data inversion in the system under test.

If a loss of synchronization is detected between the incoming data and pattern generator after synchronization has been obtained, the unit will automatically resynchronize the receive-pattern generator, turn on the SYNC LOST indicator and restart the measurement. The SYNC indicator will always be illuminated when the FIREBERD has obtained synchronization. It must be illuminated for the test to proceed.

4.3.5 Control Panel

The control panel provides all front-panel switches, indicators, and displays. Switch outputs are encoded and debounced, and passed directly to the processor input ports or to other hardware logic. The processor drives the 6-digit display, the tone generator, and some indicators.

4.3.6 Processor

The processor serves as the controller and computer for the test set. It scans the controls and inputs signaling, and status information from various circuits in the instrument. This information is used to compute the status outputs which are provided to the indicators, tone generator, and printer interfaces. It is also used to derive the control signals which originate via IEEE-488 commands (see Section 6.5).

An RS-232 Printer Interface is provided on each unit and an optional IEEE-488 Interface is available. The processor determines when data is to be printed according to front-panel controls and test events. When data is to be output, the data is fed into a 512 byte FIFO (First In, First Out) memory. The FIFO allows the processor to store data to be printed, as it occurs, until the printer has time to print it.

4.3.7 Power Supply

The power supply provides filtered and well regulated DC voltages to all circuitry within the FIREBERD. The instrument case incorporates an internal metalized coating and line filter to minimize EMI/RFI susceptibility. The power supply also provides circuitry to monitor the main DC supply inside of the FIREBERD. If the supply drops below a predetermined level due to power line failures, the microprocessor will be reset and a power-up message will be sent to the printer interface.

SECTION 5
OPERATION

5.1 INTRODUCTION

This section provides a detailed description of measurement capability and possible measurement configurations. This is followed by a discussion of factors to consider (such as timing modes and parameter selection) when using the instrument. The last section provides a step-by-step operating procedure which may be used as an operating guide.

5.2 MEASUREMENT CAPABILITY

5.2.1 Error Analysis

The FIREBERD 1500A measures errors, errored seconds, seconds, error free seconds, percent error free seconds, blocks, block errors, BER (Bit Error Rate), and elapsed time. These are defined as follows:

Error - an error is counted when a bit is received which has a value different than the value that was transmitted.

Errored second - an errored second is counted each time a test second ends in which one or more errors occurred.

Test seconds - the number of seconds since the test started.

Error free seconds - an error free second is counted each time a second occurs with no errors counted (printed result only).

Percent error free seconds - the percentage of seconds since the test began in which no errors were detected.

Block - a block is counted each time the number of bits received since the end of the last block equals the block length, as set by the MODE switch.

Block error - a block error is counted when the block count is incremented if any of the bits in the block were in error.

BER - Bit Error Rate is defined as the total number of errors counted, divided by the total number of bits used to perform the measurement.

Elapsed time - elapsed time is the time since the FIREBERD was powered up.

All measurements start immediately after synchronization is acquired. All measurements continue until: synchronization is lost, the test is restarted by toggling the RESET switch, or when the position of the MODE switch is changed.

5.2.2 Operating Modes

Each of the three measurement modes (BER, Single Error, and Block) provide different sets of measurement results.

BER measurements may be made in one of two modes. Fixed length BER measurements are performed over a number of bits determined by the MODE switch (see Section 4.2.1 for a description). Each time a full BER measurement interval has been completed, the BER measurement will be restarted. When at least one full BER measurement interval has been completed, the result from that measurement interval is complete and the old BER result will be replaced with the new value.

Auto BER Mode requires that more than 99 errors have been accumulated and a BER measurement interval (10^5, 10^6, 10^7, etc.) has been completed before a result is sent to the display, tone generator, and printer. In Auto BER Mode, the test set will continually test for a result with greater than 99 errors at the completion of each BER interval. The result will be output at the end of the first test interval which includes more than 99 errors. If the 10^{10} interval is completed and the result has less than 100 errors, a LESS THAN 100 ERRORS message will be printed with the result.

In either of the BER Modes, the result is displayed in the format X.XXE-X. For measurement results with more than 99 errors, the display format will be scientific notation, e.g., 1.03E-6. If a fixed length BER measurement result has less than 100 errors, the result will be displayed with a mantissa less than one, e.g., .99E-6 (99 errors in one hundred million bits). If the measurement result has less than 10 errors, the result will be displayed with a mantissa less than .1, e.g., .09E-6 (9 errors in one hundred million bits). The intent of this display format is to warn the operator when the result being displayed may not contain enough errors to be statistically reliable.

Single Error Mode is used to test each of the incoming data bits. If any of the data bits are in error, they will be displayed via the DISPLAY SELECT: ERRORS/ERR SEC/SEC switch. This mode also provides errored seconds and test seconds (seconds since test was started). An errored second is counted each time one or more errors occur in a test second.

Block Mode segments the incoming data bits into block lengths dependent on the position of the Block Mode switch (10^3, 10^4, 10^5 bits). A block is counted after receiving the appropriate number of data bits. For example, in the 10^3 position one block is added to the display every 1,000 data bits.

A block error is counted when one or more bit errors have occured in any one block. The block error is added to the display when that block is complete.

Blocks and block errors may be selected for display via the DISPLAY SELECT: BLOCK ERRORS/BLOCKS switch.

5.3 MEASUREMENT CONFIGURATIONS

Figure 5-1 shows four possible measurement modes for system testing with the FIREBERD 1500A. Figure 5-1a shows local-system testing. One FIREBERD test set is used to test a modem or communication system which has its transmit output looped back to its receive input. Figure 5-1b shows a simplex end-to-end test. This configuration requires two test sets located at opposite ends of the link. One test set generates data and sends it into the communication system. The other test set receives the data, performs the error analysis, and displays the results. Figure 5-1c shows a full-duplex

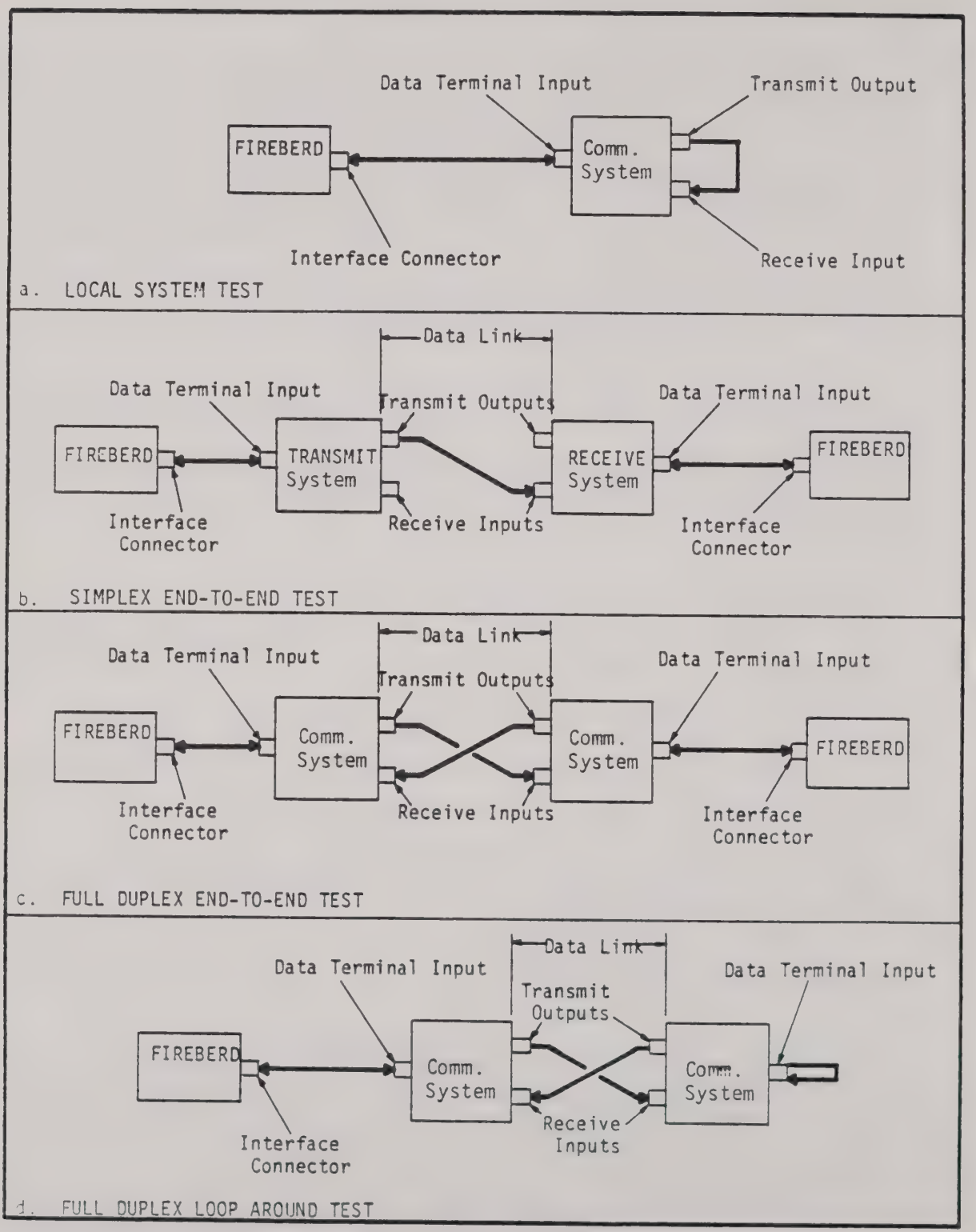

Figure 5-1 Measurement Modes

end-to-end test. This test is similar to the simplex test except that testing is simultaneously performed in both directions. Two test sets are used for measurements, each test set displays the results measured by its receiver. Figure 5-1d shows a full-duplex loop-around test. The data is looped around at the digital side on the remote end of the communication system[1].

Figure 5-2 shows various points as which FIREBERD test sets could be connected to a communication system for error analysis. Various combinations of the above measurement modes can be used to test the entire system. Some of the possible tests are listed below:

a. FIREBERD #1 with local modem looped back.

b. FIREBERD #1 with remote low-speed modem looped back.

c. FIREBERD #1 with remote loopback at the terminal 4 output of the remote multiplexer.

d. FIREBERD #1 to #2, full or half duplex

e. FIREBERD #3 to #4, full or half duplex

f. FIREBERD #2 to #5, full or half duplex. Note that FIREBERD #2 must act as a DCE in this case since the multiplexer is configured to interface with multiple low-speed modems (DCEs).

g. FIREBERD #1 to #5, full or half duplex. Note that FIREBERD #2 may be operated with a bridging interface to simultaneously measure performance part way through the system.

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[1] The total errors counted will normally equal the sum of the errors caused by each pass through the link. If the error rate is extremely high, the measured error rate will be slightly less than the sum of the error rates for each direction because errors in one direction will occasionally cancel errors in the other direction.

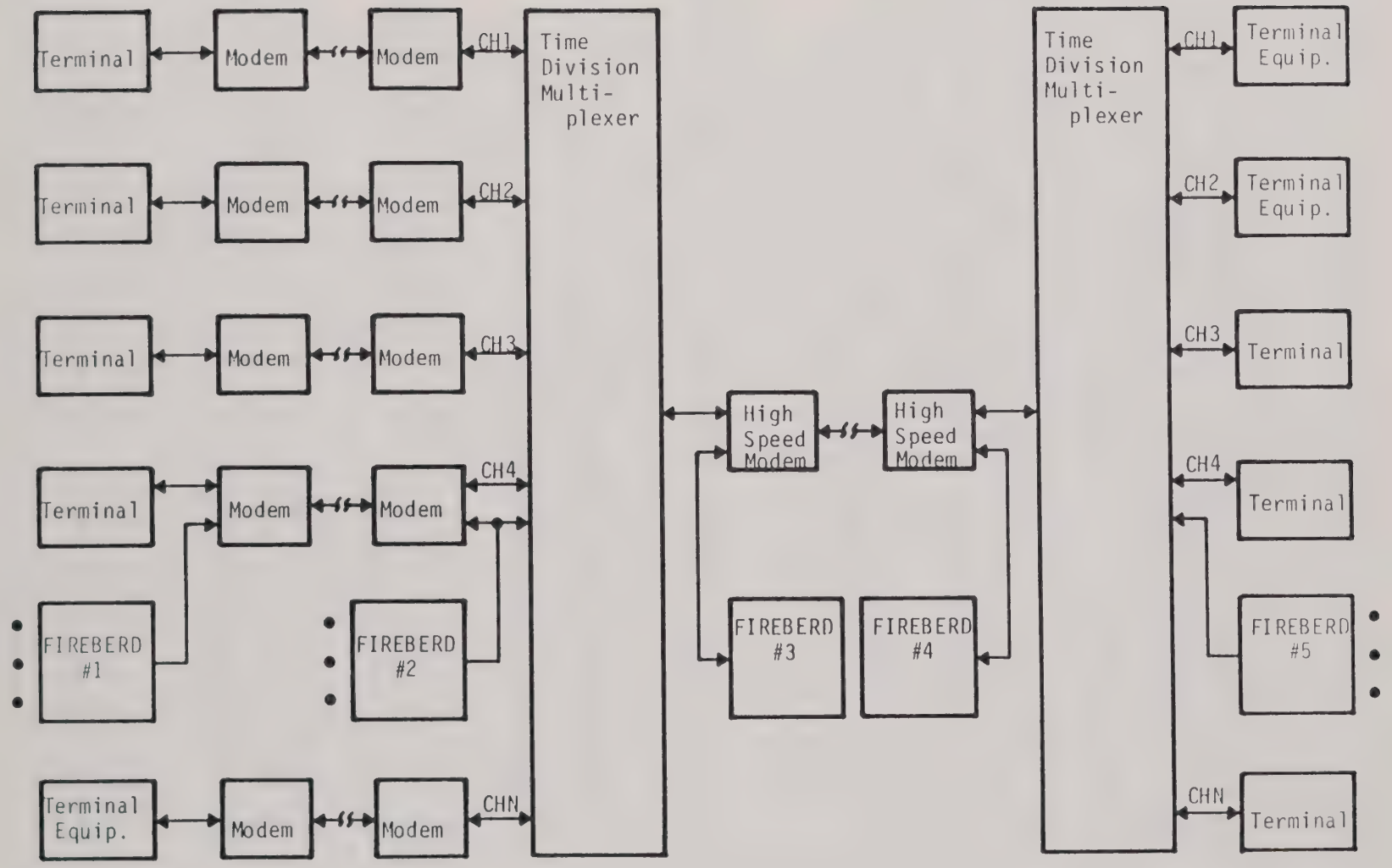

Figure 5-2 Measurement Configurations

5.4 OPERATING CONSIDERATIONS

5.4.1 Synchronous DTE Timing Modes

The FIREBERD is capable of operating as synchronous data terminal equipment (DTE) with many of its interface modules (exceptions include the RS-232 Character and T-Carrier-type interface modules). Figure 5-3 shows the four possible synchronous timing modes.

Figure 5-3a shows the FIREBERD providing transmit timing and data at one of the standard internal rates or with an optional frequency provided in FA, FB, FC, or FD. Receive timing and data are provided by the DCE. Figure 5-3b shows the FIREBERD receiving external transmit timing from the DCE. The external timing is used to generate transmit timing and data which is sent back to the DCE. The DCE provides receive data and timing. Figure 5-3c shows the FIREBERD using timing supplied through the BNC connector to generate transmit clock and data. The DCE provides receive data and timing. Figure 5-3d shows the FIREBERD receiving external timing from the DCE and generating transmit data with this timing. This mode of operation is similar to the mode shown in Figure 5-3b except that the DCE does not accept the transmit timing which accompanies the transmit data. Care must be used with this timing mode at very high speeds. The delay caused by the cable along with the delay in generating transmit data from the external transmit clock causes a phase shift between the transmit data received at the DCE and the transmit timing sent out by the DCE. At high speeds, this delay may become a significant fraction of the data period and cause invalid clock-data phasing at the DCE. The individual interface specifications in Section 7 provide actual values for the delay between the received external clock and transmitted data. This information along with the cable length may be used to compute the maximum operating frequency for this timing mode.

Any of the timing configurations shown in Figure 5-3 may be used for half-duplex as well as full-duplex or loop-around testing. In half-duplex operation, either the transmit or the receive clock and data will not be used.

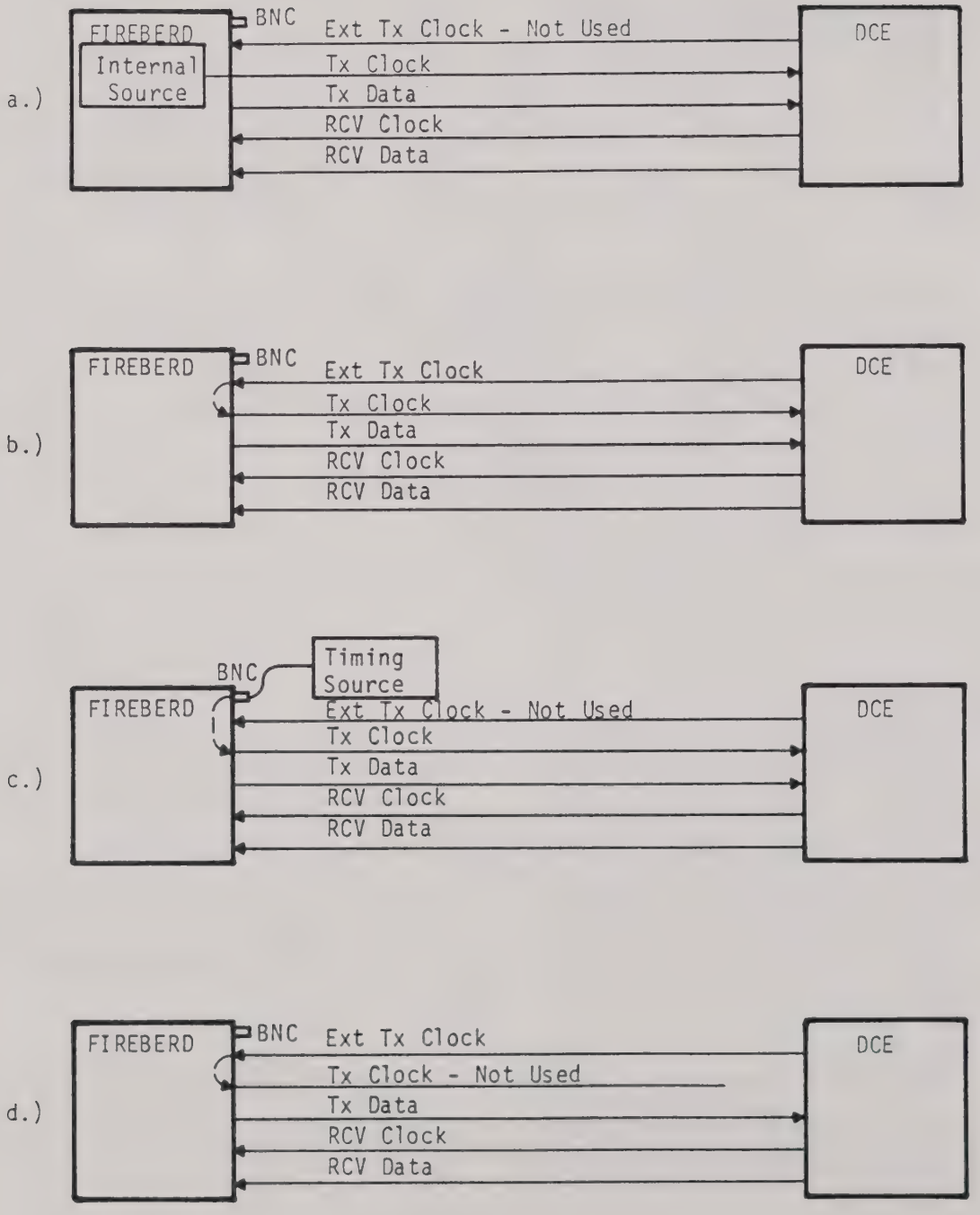

Figure 5-3 Synchronous DTE Timing Modes

When the TEST switch is placed in the LOOP position, the outgoing transmit clock and data outputs get connected to the receiver clock and data inputs. This allows the loop test to be performed with one of the internal standard frequencies or an external transmit clock. If a loop test is performed with the GENERATOR CLOCK switch in an EXT position and no external clock is provided, no data will be generated and the test will be unsuccessful. In this case, the GEN CLK ACTVY indicator will be off, indicating the lack of a transmit clock.

When the TX CLK (transmit clock) switch (on the interface module) is in the NORM position, the phasing between the external transmit clock and transmit data, and the phasing between the outgoing transmit clock and data is as specified by the interface specification in use[1]. When the switch is in the INVERT position, both of these clock-data phase relationships are reversed.

When the RC CLK (receive clock) switch is in the NORM position, the FIREBERD expects to see receive clock-data phasing consistent with the interface specification in use[2]. In the INVERT position, the FIREBERD expects to see the opposite phasing.

In loop test, both the TX and RCV CLK switches should be in the same position (either NORM or INVERT) to ensure valid results.

5.4.2 Synchronous DCE Timing Modes

The FIREBERD is capable of acting as synchronous data communications equipment (DCE) with the RS-232 DTE/DCE, V.35 DTE/DCE, and the RS-449 DTE/DCE Interface Modules. Figure 5-4 shows six possible timing modes for DCE operation.

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[1] Most interface specifications require transmit data to be valid on the falling edge of the transmit clocks.

[2] Most interface specifications require receive data to be valid on the falling edge of the receive clock.

Figure 5-4a shows the FIREBERD providing receive clock and data to the DTE at one of the internal rates. The DTE provides transmit clock and data. Figure 5-4b is the same as 5-4a except the DTE uses the external transmit clock supplied by the FIREBERD to provide transmit timing. Figure 5-4c is the same as 5-4b except that the DTE does not provide transmit clock loop-around. In Figure 5-4d, timing is provided to the FIREBERD through the BNC connector (GENERATOR CLOCK switch in EXT BNC position). This timing is used to generate receive clock and data, and is sent to the DTE for transmit timing. Figure 5-4e shows a configuration which is the same as 5-4d except that the DTE does not provide loop-around for the transmit clock.

The final timing mode is shown in Figure 5-4f. The DTE generates transmit clock and data at an internal rate and sends it to the test set which performs error analysis on it and loops the timing to generate receive data and timing.

In any of the timing modes where an internal clock source is shown inside the FIREBERD (5-4 a, b, or c), the GENERATOR CLOCK switch should be set at one of the internal standard frequencies, FA, FB, FC, or FD. In any of the timing modes where the FIREBERD generates data from a clock supplied through the BNC input or from the DTE (5-4d, e, or f), the GENERATOR CLOCK switch should be in the EXT BNC or EXT I/F position.

The FIREBERD acts as a DCE and transmit timing originates in the FIREBERD or from its BNC input (Figure 5-4b, c, d, or e), a switch on the interface module prepares the FIREBERD to interface with a DTE which: (1) will loop the transmit timing back to the

FIREBERD, or (2) will not loop the transmit timing back to the FIREBERD.

5.4.3 Asynchronous (Isochronous) or Self Clocked Timing Modes

Several interface modules allow the FIREBERD to test systems where timing information is not transmitted separately from the data. These interface modules have clock-recovery circuits which recover the timing information from the received data.

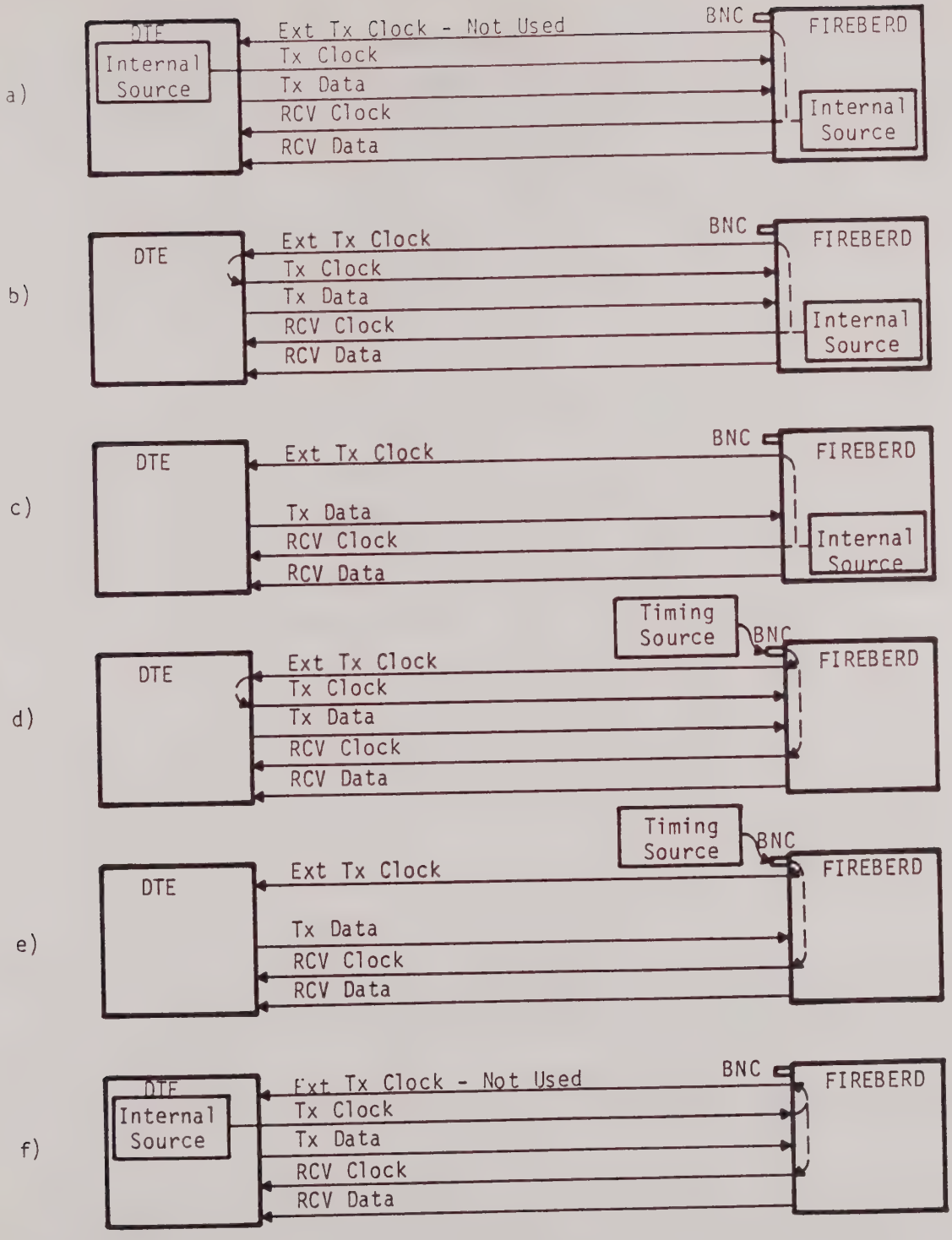

Figure 5-4 Synchronous DCE Timing

The available sources of transmit timing depend on the interface module and the operating modes selected, but in general are:

1. The recovered receive-clock signal.
2. A timing source (e.g. an oscillator) located on the interface module.
3. One of the standard FIREBERD clocks or an optional clock installed as FA, FB, FC, or FD.
4. The rear-panel BNC connector.

Some of the interface modules which have clock-recovery circuits are:

- o RS-232 Synchronous/Isochronous DTE
- o T1 D4 (Framed/Unframed)
- o T1 (Unframed) with APS
- o CCITT G.703 64 kb/s Co-directional
- o CCITT G.703 2.048 Mb/s
- o MIL-188C/MIL-188-114 Unbalanced
- o MIL 188-114 Balanced
- o DS1C/DS2

5.4.4 Parameter Selection

5.4.4.1 Introduction

The following sections are provided to help the user select test parameters such as: BER test length, block length, pattern, and synchronization mode.

5.4.4.2 BER Test Length Selection

The BER test length should be chosen such that enough errors are accumulated during the measurement interval to produce a statistically reliable result. If the errors in the received data are statistically independent, a test length which collects more than 100 errors will provide a result within $\pm$ 20% of the true average error rate with a 94% confidence level.

In some cases, errors may not be statistically independent. Differential encoders, self-synchronizing scramblers, other devices in the communications system, or channel characteristics may cause errors to occur in groups. If this is the case, the test length should be chosen to accumulate a larger number of errors to ensure reliable results. Generally, if AUTO BER MODE is used or if the test length is set to be two orders of magnitude above the reciprocal of the anticipated BER, reliable results will be produced.

5.4.4.3 Block Length Selection

Block error measurements are useful in determining information about the statistics or distribution of errors. If BER measurements are performed on the channel and if block and block error measurements are also performed, information on the error distribution may be deduced. For example, if the BER is 1×10^{-5} over a 10^7 bit test interval and 100 10^5 -bit blocks are received with only two block errors, it can be inferred that the errors are occurring in bursts. If the test were repeated with 10,000 10^3 -bit blocks and only several block errors were counted, it can further be inferred that the errors are occurring in relatively short bursts (less than 1000 bits).

The errored seconds measurement may be used to obtain a block length equal to the number of bits per second received. For example, at 56,000 b/s, each second counted corresponds to a block of 56,000 bits and each errored second is a block error for the 56,000 bit block length.

5.4.4.4 Pattern Selection

The FIREBERD provides three patterns which are not pseudorandom in nature: Mark, 1:1 (Alternate Mark - Space) and 1:3 (1 Mark followed by three Spaces). These patterns may be used for signal tracing or error analysis. It should be noted that some communications systems may not function normally with some of these non-random patterns.

Five different pseudorandom patterns with the following lengths (in bits) are provided: $2^6-1=63$, $2^9-1=511$, $2^{11}-1=2047$, $2^{15}-1=32767$, and $2^{20}-1=1048575$. Each of these patterns repeats with a time period equal to the pattern length (in bits) times the bit

period (in sec/bit). Each 2^N-1 length pattern also has the property that no more than N sequential ones or N-1 sequential zeros will ever occur. Thus, the longer pattern lengths will occasionally produce longer sequences of identical bits, and thus, longer sequences of data with no transitions. This is important for testing certain systems with clock recovery since long sequences of data with no transitions will stress clock-recovery loops and indicate clock-recovery problems.

5.4.4.5 Synchronization Mode Selection

The FIREBERD should normally be operated in the ENABLE position of the AUTO SYNC switch. This allows the unit to synchronize to the incoming data and measure error rates up to 10^{-1}. In this mode, the unit will synchronize and restart the test when the receiver detects more than 100 errors in any group of 1000 bits. Any true loss of synchronization will cause a 50% error rate to be detected by the receiver and cause a resynchronization.

The DISABLE position of the AUTO SYNC switch is used when bursts of errors may produce error rates higher than 10^{-1} over 1000 bit intervals. In this mode, resynchronization is inhibited once synchronization has initially been obtained. Internal error counters will not overflow even at 100% error rates until the result becomes larger than six digits (display size). The internal counters used for BER measurements will not overflow under any circumstances. The disadvantage of using Auto Sync Disable mode is that if a true loss of synchronization occurs[1] it will not cause resynchronization. In this event, the measured BER will be 0.5. As a warning of possible loss of synchronization, the SYNC LOST light will flash for 5 seconds if the error rate exceeds 10^{-1} in Auto Sync Disable mode.

5.4.5 Interface

5.4.5.1 Interface Selection

The user should be careful to choose an interface module which is appropriate for the system to be tested. This involves choosing a module which meets the appropriate

interface specification, operates in the correct mode (DTE or DCE), and that functions in a compatible timing configuration (synchronous, character, or asynchronous (isochronous)).

Interface modules are available with the FIREBERD which meet the following standard interface specifications: EIA RS-232, EIA RS-449, CCITT V.35, Bell 306, Bell DS- (DS0, DS01, DS1, DS1C, DS2), WECO 303, CCITT G.703, and Military (MIL 188-114 and MIL 188C). If the interface specification for the system under test is not one of the above, the user should consider whether the LAB Interface Module may be used or if one of the standard interface modules may be used to interface with the system under test.

An interface module with synchronous capability should be used when a clock signal accompanies the data at the interface for the system under test. Asynchronous (isochronous) interface modules should be used to test systems where clock does not accompany the data. Many low-speed asynchronous modems fall into this category. Character interface modules should be used to test systems where clock does not accompany the data and where the system has an asynchronous character interface.

Systems with this type of interface usually strip the start and stop bits off of the data before passing it through the link and add the start and stop bits back on at the remote end of the link.

5.4.5.2 Interface Operating Considerations

All interface modules have some sort of operating speed limitations. Character and asynchronous (isochronous) interface modules are designed to function at predefined operating frequencies or frequency ranges. The period of the received data bits must be within a specified percentage of the design frequency for proper operation. Section 7 specifies the appropriate limits. Interface modules operating in a synchronous mode will have maximum operating speeds which are a function of cable length and other parameters

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[1] Such as when a clock slip occurs.

for the particular interface in use (refer to Section 7 for details). Synchronous interface modules provide clock switches for inverting either the transmit or receive clocks. These switches should be placed in the NORM position unless it is known or suspected that the system to be tested employs non-standard data-clock phasing.

5.4.6 BNC Clock Input

The BNC Clock Input on the FIREBERD rear panel is selected by the GENERATOR CLOCK TX (RCV) switch EXT BNC position. The BNC connector is AC coupled to a differential-line receiver with a 2K input impedance from either input to ground. The receiver is designed to accept unipolar or bipolar, balanced or unbalanced signals greater than 1 V_{pp} in amplitude. When a unipolar signal is used, it is advisable to provide a ground between the BNC shield and the rear-panel ground test point or ground stud.

The high impedance of the line-receiver input was designed to allow interfacing with RS-232, RS-423, and TTL drivers. A termination resistor equal to the characteristic impedance of the line which drives the BNC input should be used when the BNC input is used with a signal which has a high frequency or fast rise and fall time.

The differential voltage applied between the two BNC conductors should be kept less than 25 volts and the magnitude from either input to ground should be less than 25 volts. If the voltage at either BNC input exceeds 13 volts, the input impedance will drop from 2K ohms down to about 75 ohms due to internal diode-protection circuits.

5.4.7 Measurement Limitations

The FIREBERD 1500A is specified to run to frequencies down to 50 Hz for synchronous or asynchronous (isochronous) modes of operation with no restrictions. Operation below 50 Hz is possible for synchronous operation only.

The FIREBERD 1500A requires typically less than 400 data bits to acquire sync. Therefore, the time it takes to synchronize to a data stream will be noticeably slower at lower data rates.

The upper operating frequency range of the FIREBERD 1500A depends directly on the interface module installed and the operating mode of the interface modules. Typical upper limits for several of the common interface standards are given below:

RS-232-C	20 kb/s
MIL-188C	60 kb/s
MIL-188-114 Unbalanced	130 kb/s
MIL-188-114 Balanced	13 Mb/s
RS-449 (RS-423 Unbalanced)	130 kb/s
RS-449 (RS-422 Balanced)	10 Mb/s
V.35/306	10 Mb/s

Operation at rates higher than 10 Mb/s is possible if careful attention is paid to duty cycles, clock-data phasing and skew, and proper cable terminations.

5.5 OPERATING PROCEDURE

The following step-by-step sequence may be followed to perform error-analysis measurements with the FIREBERD. It is intended to serve as a guide and is not the only operating sequence.

1. Select a measurement configuration. If loop-around testing is to be performed, only one FIREBERD will be required. If end-to-end testing is desired, two FIREBERDS will be required and the procedure should be followed for the unit at each end of the link. Section 5.3 provides information on measurement configurations.

2. Set the FIREBERD for the appropriate line voltage. See Section 2.4 for details on line voltage selection.

3. If a printer is to be used, connect it to the appropriate printer interface and turn it on. Set the front-panel printer controls to the desired positions. If a TTC PR-2000 Thermal Printer is to be used, set

each of the rear-panel RS-232 DIP switches in the up position. If a different rear-panel RS-232 printer is to be used, see Table 3-1 for the setting of this DIP switch. If the IEEE-488 Interface is used, set the rear-panel IEEE-488 DIP switches to the appropriate positions and properly configure the IEEE-488 printer. Section 6 provides information on the printer interfaces. Section 4.2 provides a description of each switch and indicator on the FIREBERD.

4. Select the appropriate interface module for the test. When making the choice, consider the following:

   The applicable interface specification; whether the FIREBERD will need to act as a DTE or DCE; whether the FIREBERD will run in a synchronous, asynchronous (isochronous), or character (asynchronous) timing mode.

   Section 7 provides detailed information on each interface module.

5. Determine the timing mode. Set the switches on the interface module and the FIREBERD GENERATOR CLOCK TX (RCV) switch to the appropriate positions. If the interface module has CLOCK switches, these switches should normally be set to the NORM position. Sections 5.4.1 through 5.4.4 and Section 7 provide applicable information.

6. Connect the interface cable from the system under test to the interface module. Connect the power cord from the AC supply to the AC input on the FIREBERD rear panel. Connect the external clock to the rear-panel BNC input if necessary. Turn the FIREBERD power switch to the ON position.

7. Set the PATTERN and AUTO SYNC switches to the desired positions. Set the MODE switch to the SINGLE ERROR MODE position. For full duplex testing, both FIREBERDs must have their PATTERN switches in the same position. Section 5.4.5 provides information on selection of these parameters. Section 4.2 provides a description for each switch.

Place the RESULT HOLD/UPDATE/RESET switch in the UPDATE position.

8. Set the RTS/RLSD switch to the position required by the system under test. If in doubt, turn it ON.

9. Set the remaining switches as follows:

DATA - NORM
AUDIO - as desired
ERROR INSERT - OFF
TEST - LOOP
DISPLAY SELECT - ERRORS
RESULT HOLD/UPDATE/RESET - press and release

The FIREBERD should now be operating with its transmitter looped back to its receiver. The following indications should be present:

a. The GEN CLK ACTVY indicator should be on: If it is not and the GENERATOR CLOCK TX (RCV) switch is in the FA, FB, FC, or FD positions, no optional oscillator is present in the selected position. If the GENERATOR CLOCK TX (RCV) switch is in an EXT position and no activity is present, the external clock is not being received. Check the levels of the signal applied to the BNC connector if BNC is in use. Check the interface module switch positions and verify the presence of an external clock at the interface module input if one is required for the timing mode in use. Refer to Sections 5.4.1 through 5.4.4 and Section 7 if necessary.

b. The RCV CLOCK (TX CLOCK for DCE operation) indicator should be illuminated. The RCV MARK/TX MARK and RCV SPACE/TX SPACE indicators should be on or flashing, depending on the operating speed and position of the PATTERN switch. If

these are not present, verify that the interface module is not being operated above its maximum speed limit.

c. The SYNC indicator should be illuminated. If it is not, check the interface module switches and maximum speed limit. Note that the DS1 Interface may not be run in loopback with recovered receive timing used for transmit timing.

d. The display should show zero errors.

Now toggle the ERROR INSERT switch to the SINGLE position and verify that the error count on the display increments each time the switch is toggled. Once successful operation has been achieved in loopback, you are ready to operate through the system under test.

10. Place the TEST switch in the NORM position and press and release the RESET switch. The RCV CLOCK (TX CLOCK for DCE operation) and the SYNC indicator should be illuminated. The test set is now operating through the communication system. Unless the system error rate is high (10^{-4}) a 10^{-3} error rate may be inserted into the generated data stream to verify the data path. For loop-around testing, the inserted errors should be counted by the unit which inserted them. For end-to-end testing, errors inserted at one end should be counted at the other location.

11. Now that the unit is operating through the system, switch the ERROR INSERT to OFF. Press and release the RESET switch to start the test. Note that changing the PWR, MODE or interface module switches (on some interfaces) will cause a test restart and force a resynchronization.

SECTION 6
PRINTER INTERFACES AND PRINTOUT FORMATS

6.1 INTRODUCTION

This section defines the data-output format and the interface characteristics of the RS-232 and the optional IEEE-488 Printer Interfaces. The interfaces are not intended to be operated simultaneously. If a device connected to the RS-232 Printer Interface holds the Data Terminal Ready line ON, this device receives the data and the IEEE-488 Interface is ignored by the FIREBERD.

The following sections provide information on data-output formats and the events which initiate data output to the printer interfaces.

Information on the PR-2000 RS-232 Thermal Printer is provided in the PR-2000 Operating Manual (ML10292).

6.2 PRINTOUT FORMATS AND EVENTS WHICH INITIATE DATA OUTPUTS

6.2.1 Print Control

The PRINT CONTROL toggle switch controls outputs to the printer interfaces. It may be used to: (1) disable data output - DISABLE position; (2) initiate a result printout - PRINT position; or (3) allow result printouts to be automatically initiated - AUTO position.

When the PRINT CONTROL toggle switch is in the AUTO position, the events which initiate result printouts are dependent on the position of the MODE switch and the PRINT CONTROL EVENT switch. In BER Mode, printouts are initiated automatically at the completion of each BER measurement as determined by the BER test length. In BER Mode, the PRINT CONTROL EVENT switch is not operable. In Single Error or Block Mode, printouts are initiated automatically at events selected by the PRINT CONTROL

EVENT switch. With this switch in the ERR position, a printout is initiated on the occurrence of each errored second and once every hour of the ongoing test. The 1, 10, and 30 positions initiate printouts at 1, 10, and 30 minute intervals.

6.2.2 Result Printouts

Result printouts provide all of the test data related to the ongoing test along with the elapsed time since the power was turned on. The following are typical result printouts:

BER MODE RESULT:	TIME	0:00:53
	TEST LENGTH	1E06
	BER	0.00E-3
SINGLE ERROR MODE RESULT:	TIME	0:00:17
	ERR FREE SEC	16
	% ERR FREE SEC	94.1
	ERR SEC	1
	TEST SEC	17
	ERR	1
BLOCK MODE RESULT:	TIME	0:00:35
	TEST SEC	10
	BLK ERR	0
	BLK	104

The top line of all result printouts provides the operator with the elapsed time (TIME) since power-up of the FIREBERD.

The BER Mode printout shows that the ongoing test has measured a BER of zero (BER 0.00E-3) and that the last BER measurement was performed over one million bits of data (1E06).

The Single Error Mode printout contains the seconds of the test containing no errors (ERR FREE SEC), the percentage of seconds containing no errors (% ERR FREE SEC), the seconds containing errors (ERR SEC), the total seconds of the test (TEST SEC), and the total errors (ERR).

The Block Mode printout contains the total seconds of the test (TEST SEC), the number of blocks in error (BLK ERR), and the number of blocks received (BLK).

6.2.3 Status Messages

Status Messages are output to the printer on the occurrence of events which may affect the test in process. The following descriptions provide information on each of the status messages:

1. The Self Test message is sent to the printer interface when the FIREBERD is powered up. This message should read "SELF TEST PASS". If a "SELF TEST FAIL" message is printed, turn the power off and check all connections to the FIREBERD. If the "SELF TEST FAIL" message is printed when power is reapplied, see Section 9.

2. The Power On (PWR ON) message is sent to the printer interface when the FIREBERD is powered up.

   ```
   TIME     0:00:00
   PWR ON
   ```

3. The Sync Acquired status message is sent to the printer interface when the receiver section of the FIREBERD has synchronized to the incoming data. The time of the synchronization is also printed.

   ```
   TIME     X:XX:XX
   SYNC ACQUIRED
   ```

4. The No Sync status message is sent to the printer interface when the receiver section of the FIREBERD has not synchronized to the incoming data. The time is also printed.

```
TIME      X:XX:XX
NO SYNC
```

5. The Sync Loss message is sent to the printer interface when the receiver section has lost synchronization to the incoming data. This message also includes the time that synchronization was lost.

```
TIME      X:XX:XX
SYNC LOSS
```

6. A Test Restart message is sent to the printer interface on the occurrence of a manually activated Test Restart (when the RESET switch is toggled, the MODE switch is changed or when an IEEE-488 reset command is received).

```
TEST RESTART
```

7. The Receive Clock Loss message is sent to the printer interface when the clock signal used by the FIREBERD receiver is no longer detected. This clock is the receive clock for emulate DTE operation and the transmit clock for emulate DCE operation. The instrument does not have to be synchronized to the incoming data to detect a Receive Clock Loss.

```
RCV CLOCK LOSS
```

8. The Buffer Full message is sent to the printer interface when the FIREBERD printer buffer is unable to accept new data. The buffer can contain approximately 28 complete Single Error Mode results before overflowing. No more printer data is accepted into the buffer until it is down to 80% full.

9. The Less Than 100 Errors message is sent to the printer interface only in Auto BER Mode when the 10^{10} Bit Test Length is completed and less than 100 errors have been accumulated.

```
TIME          X:XX:XX
TEST LENGTH   1E10
BER           0.00E-8
LESS THAN 100 ERR
```

10. The 60 Minute Print message is sent to the printer interface every 60 minutes when the PRINT CONTROL EVENT switch is in the ERR position and the FIREBERD is operating in the Single Error or Block Mode. This message serves to differentiate result prints which are initiated every 60 minutes from those which were initiated on the detection of errors.

```
60 MINUTE PRINT
```

11. The double asterisks printout is sent to the printer interface on the occurrence of an overflow with the two asterisks printed next to the value that just overflowed. Each result printout following the initial overflow has a single asterisk printed next to the overflowed value.

6.3 DATA BUFFERING

Both the RS-232 and the IEEE-488 interfaces receive their data through a 512 byte data buffer (FIFO). This buffer is capable of holding 28 data results before outputting a BUFFER FULL message. Once the buffer is full, it does not accept data until it is down to 80% full. Data outputting to the printer interface continues until the buffer is completely empty or when the buffer is manually cleared. The buffer may be manually cleared by setting the PRINT CONTROL switch to the DISABLE position. The FIFO will be cleared at the end of the current printout.

6.4 RS-232 PRINTER INTERFACE

6.4.1 General Description

This interface provides serial asynchronous data with the levels, connector, and pin-outs as specified by EIA standard RS-232C. The interface is set up such that the FIREBERD 1500A acts as data communications equipment (DCE) sending data to data terminal equipment (DTE) (printer). Four signal lines are implemented: signal ground, protective ground, Receive Data (RD), and Data Terminal Ready (DTR).

When the FIREBERD is ready to output data, it looks at the DTR line for an ON condition. If DTR is not ON, the printer is not connected, not turned on, or out of paper, and no output is attempted. If DTR is ON, one data byte is transmitted on the receive data line. If the DTR line stays in the ON condition after this byte has been sent, another byte will be transmitted. In this manner, the FIREBERD will continuously output data bytes to the receive data line, inserting pauses when the DTR line goes to the OFF state. This allows the printer or DTE to stop the data flow while it takes time to print a line or store the data. Once the last byte has been transmitted and DTR goes to the ON condition, the data output is complete.

6.4.2 Signal Format

Each FIREBERD is shipped with the RS-232 Printer Interface configured to run at 2,400 baud (all RS-232 DATA FORMAT switches UP). Each data byte consists of one start bit followed by: 7 data bits, one even parity bit, and 2 stop bits.

The seven-bit American Standard Code for Information Interchange (ASCII) is used to code each character. Each data line is less than 20 characters long and ends with a carriage return (ASCII character CR). A linefeed (ASCII LF) is sent after each complete data output to cause a blank line to be printed between successive printouts.

The FIREBERD sends a carriage return character at the end of each line and expects the printer to perform both a carriage return and a linefeed before beginning the next line.

For printers which do not automatically perform a linefeed after each carriage return the FIREBERD may be set to output a linefeed character after each carriage return by setting the appropriate switch on the RS-232 DATA FORMAT DIP switch (refer to Table 4-1). Note that this switch is read only on power-up.

6.4.3 Connection To Other Devices

The RS-232 Printer Interface requires only three lines to operate properly (Data, DTR, and Ground). The Data line is output from the FIREBERD printer interface at Pin 3 of the RS-232 Printer Connector. This signal consists of serial ASCII characters with start, stop, and parity bits.

The DTR (Data Terminal Ready) input is located at Pin 20 on the RS-232 Printer Connector. This input is used to tell the FIREBERD when the printer is ready to accept data. When an ON signal is input at DTR (Pin 20), the FIREBERD 1500A will begin outputing characters at the Data output (Pin 3). Ground is located at Pins 1 and 7 of the RS-232 Printer Connector.

6.5 IEEE-488 INTERFACE (OPTION 001)

6.5.1 General Description

The FIREBERD IEEE-488 Interface meets the specifications as stated in the IEEE Standard Digital Interface for Programmable Instrumentation (STD 488-1978). The IEEE-488 Parallel Bus Interface is sometimes referred to as the General Purpose Interface Bus (GPIB).

The IEEE-488 Interface has two basic modes of operation: Talk Only and Addressable mode.

In the Talk Only mode, the FIREBERD is designed to directly drive a Listen Only device such as an HP5150A Printer. In this mode, the FIREBERD should be directly connected to the printer with no other device connected to the bus.

In the Addressable mode, the FIREBERD should be connected to the 488 bus along with a controller. When the FIREBERD has data to output, it will request service from

the controller which may elect to have it output the data. In this mode, multiple devices may be connected to the bus. The controller is responsible for preventing any two devices from simultaneously driving the bus.

For either the Talk Only or Addressable mode, the actual data output is the same. The data consists of less than 20 bytes (ASCII characters) followed by a Carriage Return (CR). The data is transmitted in this format until the last byte is sent. This occurs when the FIREBERD printer interface buffer is emptied.

The carriage return is the only control character added to the end of each line of data sent to the printer. Therefore, the printer or listener should perform a carriage return and a linefeed (LF) when it receives a carriage return. The CR character is also sent when a blank line is to be printed.

6.5.2 Talk Only Mode

The Talk Only mode is selected by placing the right-most switch on the rear-panel DIP switch in the TALKER ONLY position (UP). In this position, the five address switches on the DIP switch are not applicable. The printer or other device to be connected to the FIREBERD-488 connector should be set for continuous listening. The FIREBERD acting as a Talker may be connected to the Listener with a standard IEEE-488 type cable. The interface is ready to operate provided that no device is holding the DTR line on the RS-232 Printer Interface in the ON condition.

Once the FIREBERD has decided to initiate a data output, the data will be transferred from the FIREBERD to the listening device. A standard 488 three-wire handshake between the FIREBERD and Listener will assure valid data transfer and determine the transfer rate.

6.5.3 Addressable Mode

6.5.3.1 Preparation for Use

To select the Addressable mode, place the right-most switch on the rear-panel DIP switch in the "ADBLE" (Addressable) position. Set the other switches on the DIP switch

for an appropriate address (0-30). Table 6-1 shows allowable talk and listen addresses. Although the addresses consist of seven bits, only the lower five bits are switch selectable since bits 6 and 7 are always 01 or 10 for a talker or listener. The switch positions labeled 1...5 correspond to bits 1...5 of the address. Once each of the other units on the bus has had its address selected and has been prepared for operation, the units may be interconnected and turned on.

The FIREBERD only reads the ADDRESS and TALK ONLY/ADBLE switch settings during power up or when an IEEE-488 Device Clear Command is received. Therefore, the FIREBERD must be momentarily powered down to make these switch changes, or a Device Clear or Selective Device Clear Command must be sent over the bus (see Section 6.5.4.2).

6.5.3.2 Operating Sequence

The FIREBERD uses the Service Request and Serial Poll feature of the 488 bus to allow it to alert the controller that it has data to output. The sequence of events is as follows:

a. The FIREBERD decides to initiate a data output and determines that no device is connected to the RS-232 Printer Interface.

   Since the FIREBERD is operating in the Addressable mode, it initiates a 488 Service Request by setting the 488 bus SRQ line low (True).

b. The controller periodically checks the state of the SRQ line and determines when a Service Request has been initiated.

c. If a Service Request is present, the controller sets the Serial Poll mode. The Serial Poll mode is initiated by the controller transmitting the Universal Command "Serial Poll Enable" (ASCII character "CAN") in the "Command Mode".

d. The controller sequentially polls each of the devices that have requested service. Once the Serial Poll mode has been enabled, each

TABLE 6-1

488 TALK AND LISTEN ADDRESSES

Listen Addresses									Talk Addresses								
Bits								ASCII Character	Bits								ASCII Character
b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1		b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1	
X	0	1	0	0	0	0	0	SP	X	1	0	0	0	0	0	0	@
X	0	1	0	0	0	0	1	!	X	1	0	0	0	0	0	1	A
X	0	1	0	0	0	1	0	"	X	1	0	0	0	0	1	0	B
X	0	1	0	0	0	1	1	#	X	1	0	0	0	0	1	1	C
X	0	1	0	0	1	0	0	$	X	1	0	0	0	1	0	0	D
X	0	1	0	0	1	0	1	%	X	1	0	0	0	1	0	1	E
X	0	1	0	0	1	1	0	&	X	1	0	0	0	1	1	0	F
X	0	1	0	0	1	1	1	'	X	1	0	0	0	1	1	1	G
X	0	1	0	1	0	0	0	(	X	1	0	0	1	0	0	0	H
X	0	1	0	1	0	0	1	)	X	1	0	0	1	0	0	1	I
X	0	1	0	1	0	1	0	*	X	1	0	0	1	0	1	0	J
X	0	1	0	1	0	1	1	+	X	1	0	0	1	0	1	1	K
X	0	1	0	1	1	0	0	,	X	1	0	0	1	1	0	0	L
X	0	1	0	1	1	0	1	-	X	1	0	0	1	1	0	1	M
X	0	1	0	1	1	1	0	.	X	1	0	0	1	1	1	0	N
X	0	1	0	1	1	1	1	/	X	1	0	0	1	1	1	1	O
X	0	1	1	0	0	0	0	0	X	1	0	1	0	0	0	0	P
X	0	1	1	0	0	0	1	1	X	1	0	1	0	0	0	1	Q
X	0	1	1	0	0	1	0	2	X	1	0	1	0	0	1	0	R
X	0	1	1	0	0	1	1	3	X	1	0	1	0	0	1	1	S
X	0	1	1	0	1	0	0	4	X	1	0	1	0	1	0	0	T
X	0	1	1	0	1	0	1	5	X	1	0	1	0	1	0	1	U
X	0	1	1	0	1	1	0	6	X	1	0	1	0	1	1	0	V
X	0	1	1	0	1	1	1	7	X	1	0	1	0	1	1	1	W
X	0	1	1	1	0	0	0	8	X	1	0	1	1	0	0	0	X
X	0	1	1	1	0	0	1	9	X	1	0	1	1	0	0	1	Y
X	0	1	1	1	0	1	0	:	X	1	0	1	1	0	1	0	Z
X	0	1	1	1	0	1	1	;	X	1	0	1	1	0	1	1	[
X	0	1	1	1	1	0	0	<	X	1	0	1	1	1	0	0	\
X	0	1	1	1	1	0	1	=	X	1	0	1	1	1	0	1	]
X	0	1	1	1	1	1	0	>	X	1	0	1	1	1	1	0	^

X = don't care

of the devices on the bus is prepared to accept a Serial Poll. The Serial Poll is performed by setting the 488 ATN line, addressing the device as a talker and then removing ATN. The device being polled responds with its Serial Poll Response Byte. If the FIREBERD initiated the Service Request, the Serial Poll Response Byte will consist of bit 6 (DIO Line 7) being LOW. The FIREBERD Response Byte (DIO Line 7) is HIGH if it did not request service.

e. Now that the controller has determined which device requested service, the controller terminates the Serial Poll mode by issuing the Universal Command "Serial Poll Disable" (ASCII Character "EM").

f. The controller should now address the appropriate device to listen (possibly itself) and then address the FIREBERD to talk. The FIREBERD will perform its data output with the standard three-wire handshake with each byte. On the last byte output (NULL), the FIREBERD will set the EOI line to indicate the end of the data transfer.

g. The data output is now complete and the controller may address another device to talk or send simply an Unaddress Command.

Due to FIREBERD's internal data buffering, the controller does not have to respond immediately to a FIREBERD Service Request.

The full sequence of polling is not necessary in all cases. For example, a system may have only one device that requests service. When the controller detects a Service Request, the source of the request and the appropriate action are known immediately.

6.5.4 Command Operation

6.5.4.1 Introduction

This section describes the commandable capability of the FIREBERD 1500A when operating in the Addressable mode. In this mode, FIREBERD will respond to several universal bus commands and simple ASCII character commands received via the GPIB.

6.5.4.2 Universal Commands

Universal commands are those commands sent by way of the GPIB and whose basic functions are defined in the IEEE-488 specification. The following list describes each of the commands that the FIREBERD 1500A responds to:

1. DCL (Device Clear) - This command causes the FIREBERD and every other unit on the bus to return to an individually determined "reset" state.

2. SDC (Selective Device Clear) - The SDC command is similar to the DCL in that it causes a reset. A Selective Device Clear resets only one unit on the bus as determined by the address sent with the SDC command.

   NOTE: A DCL or SCD does not cause the FIREBERD to perform its automatic self test as it does on a power-up. A "488 CLEARED" message will be printed on the occurrence of a DCL or SDC universal command.

3. GET (Group Execute Trigger) - This command when received by FIREBERD will initiate a test restart identical to that which is caused by toggling the RESET switch on the FIREBERD front panel. This command also causes all other units on the bus to take an appropriate action.

6.5.4.3 ASCII Character Commands

A character command is a series of ASCII characters transmitted over the GPIB data bus with the Attention (ATN) line unasserted (False). These commands cause the FIREBERD to perform specific functions which may or may not be accessible through the front panel of the FIREBERD. The following list describes each command the FIREBERD 1500A will respond to:

1. PRFC - Print Force is used to force a result print. This function is identical to manually pressing the PRINT switch.

to perform specific functions which may or may not be accessible through the front panel of the FIREBERD. The following list describes each command the FIREBERD 1500A will respond to:

1. PRFC - Print Force is used to force a result print. This function is identical to manually pressing the PRINT switch.

2. PROV - Printer Override causes the FIREBERD to ignore the RS-232 Printer Interface. After receiving this command the FIREBERD 1500A will send all data prints back to the GPIB independent of the RS-232 DTR line.

3. FFCL - FIFO Clear is used to clear the printer FIFO inside of the FIREBERD. This is equivalent to momentarily placing the PRINT CONTROL toggle switch into the DISABLE position.

4. BEEP - Beep is used to output once to FIREBERD's audio indicator. The FIREBERD will only beep if the AUDIO switch is in the HI or LO position.

5. TSRS - Test Restart will cause the FIREBERD to perform a test restart identical to pressing the RESET switch on the FIREBERD.

6. MODE - Mode returns the position of the Mode switch on the FIREBERD 1500A front panel. The position is returned as a standard line of data consisting of a single character. The character will be an upper case letter from A to K, depending on the position of the MODE switch. The following list defines these positions:

CHARACTER	POSITION
A	10^5 BER MODE
B	10^6
C	10^7
D	10^8
E	10^9
F	10^{10}
G	AUTO
H	SINGLE ERROR MODE
I	10^3 BLK LGTH
J	10^4
K	10^5

7. GPSC - GPIB with no SRQ. This command causes the FIREBERD 1500A to send all data over the bus without using the Service Request (SRQ) protocol. Therefore, the FIREBERD needs only to be addressed to talk to begin the transfer of any data in its FIFO.

8. SOCL - Clear the "no SRQ" and the RS-232 Override modes. This is used to reset the RS-232 Printer Interface override and the "no SRQ" functions back to normal (power-up state). This command only resets those two functions.

9. GPPR - GPIB to RS-232 Printer Interface is used to send each ASCII character received over the bus directly to the RS-232 Printer Interface. This provides complete control of a RS-232 printer. Only the characters received by the FIREBERD over the GPIB are sent to the applicable printer. The appropriate terminating characters must be sent to the RS-232 printer.

NOTE: To reset the GPPR Mode, a GPIB command must be sent to the FIREBERD. This command is decimal 16 (0001 0000) and must be sent with the GPIB ATN line asserted (ATN = 0 (True). All of the character commands are set to normal on a 488 DCL or SDC including the GPPR command.

Table 6-2
Printer Outputs

Message	
BER	Error Analysis BER result
BLK ERR	Error Analysis, Block Error result
BUFFER FULL	Printer Data Buffer is full
ERR	Error Analysis, Error result
ERR FREE SEC	Seconds without errors
ERR SEC	Error Analysis, Errored Seconds result
LESS THAN 100 ERR	AUTO Mode result with less than 100 errors in 10^{10} bits received
NO SYNC	Error Analysis receiver is not synchronized to incoming data
PWR ON	Power applied to FIREBERD
RCV CLOCK LOSS	RCV CLK (DTE Mode) or TX CLK (DCE Mode) is not active
SELF TEST PASS SELF TEST FAIL	Self test status messages
SYNC ACQUIRED	Synchronization Acquired
SYNC LOSS	Synchronization Lost

Table 6-2
(Continued)

TEST LENGTH	BER measurement test length (bits)
TEST RESTART	TEST RESTART initiated
TEST SEC	Error Analysis, seconds result
TIME XX:XX:XX	Time since power-up
**	The respective test data overflow just occurred
*	Test data is an overflowed value
60 MINUTE PRINT	Print out activated every 60 minutes
488 CLEARED	SDC or DCL received by IEEE-488

SECTION 7
INTERFACE MODULES

7.1 INTRODUCTION

Interface modules are used to interface the FIREBERD with any of several different types of data communications circuits. With the exception of the rear-panel EXT CLK IN BNC connector and the RS-232 printer and IEEE-488 interfaces, all signals exchanged between the FIREBERD and the "outside world" must pass through an interface module.

Section 7 contains descriptions, specifications, and operating instructions for most of the available interface modules. The following interface modules are included:

7.2 RS-449 DTE Interface Module (Models 40180 and 40263)
7.3 RS-449 DTE/DCE Interface Module (Model 40200)
7.4 V.35/306 DTE Interface Module (Model 40138)
7.5 V.35/306 DTE/DCE Interface Module (Model 40202)
7.6 WECO 303 Interface Module (Model 40182)
7.7 RS-232-C/V.24/MIL 188C Character Interface Module (Model 40392)
7.8 RS-232 DTE Interface Module (Model 40112)
7.9 RS-232 DTE/DCE Interface Module (Model 40236)
7.10 RS-232 Asynchronous (Isochronous)/Synchronous DTE Interface Module (Model 40232)
7.11 Lab Interface Module (Model 40204)
7.12 T1 Interface Module (Model 40365)
7.13 DS1/T1 (D4 Framing) Interface Module (Model 40405)

Separate manuals are available for CCITT G.703, Military, and other newly developed interface modules - consult TTC for additional information.

7.2 RS-449 DTE INTERFACE MODULE (MODELS 40180 AND 40263)

7.2.1 Introduction

The Model 40180 and 40263 DTE Interface Modules allow the FIREBERD to test synchronous communications channels utilizing EIA Standard RS-449. These interface modules enable the FIREBERD to act as data terminal equipment (DTE) for use in testing data communications equipment (DCE).

Data is exchanged in a serial-binary format with synchronous-clock signals. Data, clock, signaling, and other connections are made through a standard 37-pin female D connector (see Figure 7-1); optional 37-conductor male-to-male cables are available from TTC.

The RS-449 Interface Modules can operate with either of the two electrical interfaces specified by EIA Standard RS-449. Line drivers and receivers conforming to either RS-422 or RS-423 are switch selectable. The following section will provide functional specifications and descriptions of the RS-449 DTE Interface Module.

7.2.2 Functional Description

The RS-449 DTE Interface Module is used to connect between the TTL signals used within the FIREBERD and signals conforming to EIA Standards RS-422, RS-423, and RS-449. The interface module has three modes of operation:

1. RS-423 - In this mode, the line drivers and receivers are configured to operate with bipolar unbalanced signals at bit rates up to 100 kb/s. Signals are transmitted over the (A) lead of each signal pair with the (B) lead grounded.

2. RS-422 Terminated - In this mode, the line drivers and receivers are configured to operate with unipolar balanced signals at bit rates up

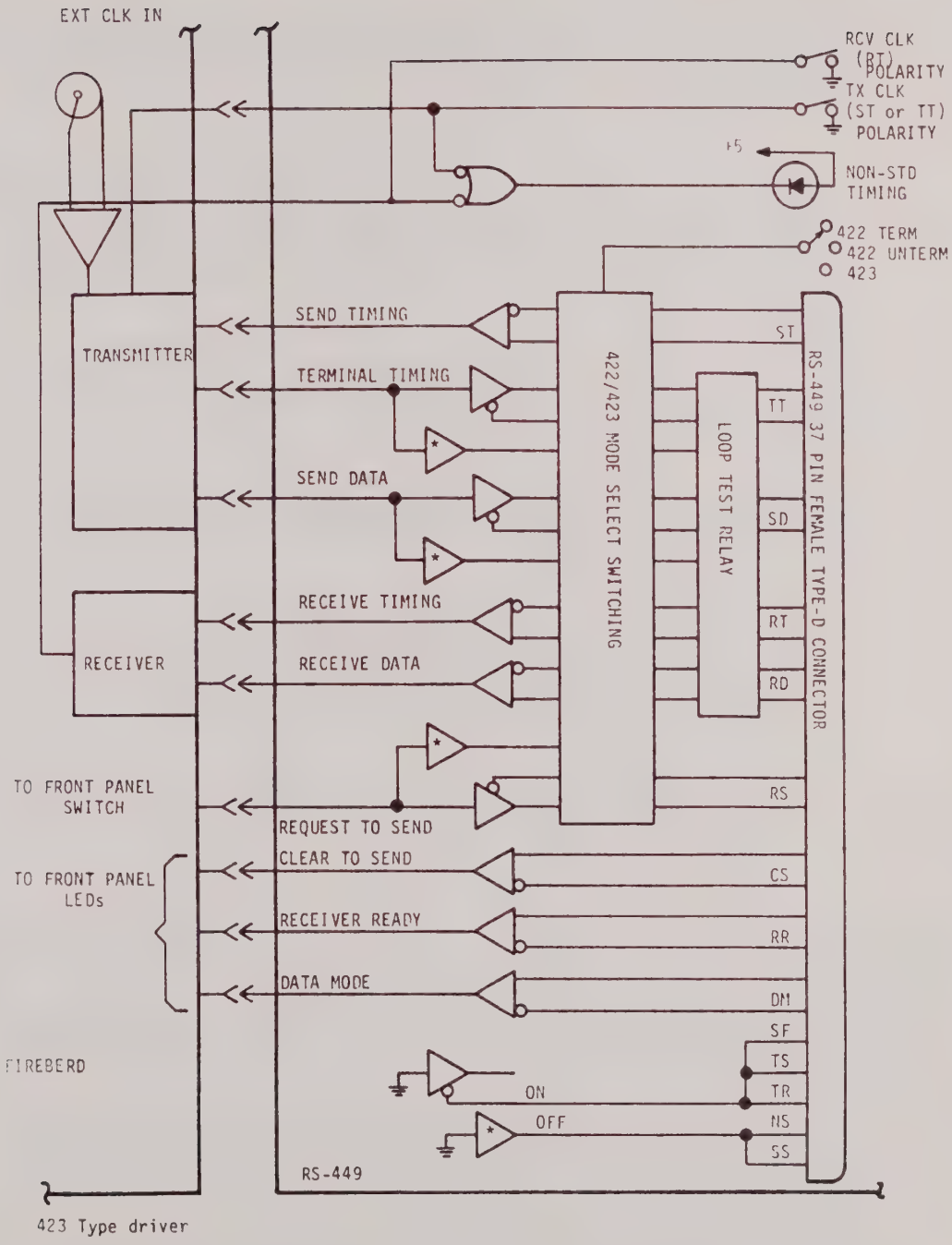


Figure 7-1. RS-449 Interface Module

to 10 Mb/s. The line receivers have 100-ohm terminating resistors between the (A) and (B) leads of the Receive Data (RD), Receive Timing (RT), and Send Timing (ST) inputs.

3. RS-422 Unterminated - In this mode, the line drivers and receivers are configured to operate with unipolar balanced signals at bit rates up to 10 Mb/s. Designed primarily to operate with short cable lengths or with low bit rates, no terminating resistors are provided.

Timing for the Terminal Timing (TT) and Send Data (SD) outputs can be obtained from any of three sources:

a. The FIREBERD internal clock frequencies including FA, FB, FC, and FD if so equipped.

b. The Interface Send Timing (ST) input. Note that the FIREBERD GENERATOR CLOCK TX (RCV) switch must be set to the EXT I/F position.

c. The rear-panel BNC connector. The GENERATOR CLOCK TX (RCV) switch must be set to the EXT BNC position.

7.2.3 Signaling

The following signals are implemented by the RS-449 DTE Interface Module and the FIREBERD:

1. Request to Send (RS) - controlled by FIREBERD front-panel RTS/RLSD switch.

2. Clear to Send (CS) - displayed on FIREBERD front-panel CTS/LT indicator.

3. Receiver Ready (RR) - displayed on FIREBERD front-panel RLSD/RTS indicator.

4. Terminal Ready (TR) - tied in the ON condition.

5. Data Mode (DM) - displayed on FIREBERD front-panel DSR/DTR indicator.

6. Terminal In Service (IS) - tied in the ON condition.

7. New Signal (NS) - tied in the OFF condition.

8. Select Frequency/Signaling Rate Selector (SF/SR) - tied to the ON condition.

9. Local Loopback (LL) - tied in the OFF condition.

10. Remote Loopback (RL) - tied in the OFF condition.

11. Select Standby (SS) - tied in the OFF condition.

7.2.4 Switches and Indicators

The following switches and indicators are found on the panel of the RS-449 DTE Interface Module:

1. 423/422 UNTERM/422 TERM - Selects the operating mode of the interface module as described in Section 7.2.2.

2. TX CLK NORMAL/INVERT - Selects the phase relationship between the Send Timing (ST), Terminal Timing (TT), and the Send Data (SD) signals. Note that the NORMAL position selects the phase relationships specified in RS-449 (falling edge valid).

3. RCV CLK NORMAL/INVERT - Selects the phase relationship between the Receive Timing (RT) and the Receive Data (RD) signals. Note that the NORMAL position selects the phase relationship specified in RS-449 (falling edge valid).

4. NON STD TIMING - This indicator illuminates when either or both of the CLK NORMAL/INVERT switches is set to the INV position.

7.2.5 Loop Test

The interface module contains a relay which allows testing of the interface module and FIREBERD data and clock-signal paths. When the FIREBERD front-panel TEST switch is placed in its lower position (LOOP), Terminal Timing (TT) is connected directly to Receive Timing (RT) and Send Data (SD) is connected directly to Receive Data (RD) by the relay, completing the loop path.

The interface cable need not be removed to perform the Loop Test as the TT, RT, SD, and RD connector pins are electrically isolated from all interface module circuitry. No other signals are affected by the Loop Test.

7.2.6 FIREBERD Test Points

This section describes the relationship between signals at the interface connector and signals at the FIREBERD rear-panel test points. The test points provide TTL-level representations of the signals at the interface connector. A logic HI is a voltage greater than 2.5 volts and a logic LO is a voltage less than 0.4 volts.

RCV DATA/TX DATA: This test point will be a logic HI when the Receive Data (RD) signal is a Mark. The test point will be at a logic LO when RD is a Space.

RCV TIMING/-: When the RCV CLK switch is in the NORMAL position, the test point is at a logic HI when the Receive Timing (RT) is in the ON condition and is at a logic LO when RT is OFF. When the RCV CLK switch is in the INVERT position, the

test point is at a logic HI when RT is in the OFF condition and at a logic LO when RT is ON.

TX DATA/RCV DATA: This test point will be at a logic HI when Send Data (SD) is a Mark and will be at a logic LO when SD is a Space.

SEND TIMING/TERM TIMING: For Model 40180, the test point will be at a logic HI when Send Timing (ST) is in the OFF condition and will be at a logic LO when ST is ON. For Model 40263, the test point will be at a logic HI when ST is in the ON condition and will be at a logic LO when ST is OFF. Use of the TX CLK switch will not affect these relationships.

TERM TIMING/RCV TIMING: For Model 40180, the test point will be at a logic HI when Send Timing (ST) is in the OFF condition and will be at a logic LO when ST is ON. For Model 40263, the test point will be at a logic HI when ST is in the ON condition and will be at a logic LO when ST is OFF. Use of the TX CLK switch will not affect these relationships.

7.2.7 Specifications

RS-449 Category-1 Circuits (RS-423/RS-422 TERM/RS-422 UNTERM):

Send Data (SD)
Receive Data (RD)
Terminal Timing (TT)
Send Timing (ST)
Receive Timing (RT)
Request to Send (RS)
Clear to Send (CS)
Receiver Ready (RR)
Terminal Ready (TR)
Data Mode (DM)

RS-449 Category-2 Circuits (RS-423 only):

Terminal In Service (IS)
New Signal (NS)
Select Frequency/Signaling Rate Selector (SF/SR)
Local Loopback (LL)
Remote Loopback (RL)
Select Standby (SS)
Test Mode (TM)

RS-422 Data Mark (binary 1), Control Lead OFF:
Lead (A) more negative than Lead (B).

RS-422 Data Space (binary 0), Control Lead ON:
Lead (A) more positive than Lead (B).

RS-423 Data Mark (binary 1), Control Lead OFF:
negative polarity.

RS-423 Data Space (binary 0), Control Lead ON:
positive polarity.

RS-422 Line Drivers:
Output differential voltage: 2.0 volts minimum.
Short circuit current: 150 mA maximum.
Output rise time: 20 nsec maximum.

RS-423 Line Drivers:
Output voltage: ± 3.5 volts minimum.
Short circuit current: 150 mA maximum.
Output rise time: 120 nsec typical (not slew rate limited) for Model 40180, 1 microsecond typical for Model 40263.

RS-422 Terminated Line Receivers:
Load impedance: 100 ohms ± 10%.
Differential input threshold voltage: ± 0.25 volts.

RS-422 Unterminated Line Receivers

Load impedance: 4000 ohms minimum for Model 40180.
2000 ohms nominal for Model 40263.

Differential input threshold voltage: ± 0.25 volts.

RS-423 Line Receivers:

Load Impedance: 2000 ohms minimum.

Input threshold voltage: ± 0.25 volts.

For connector pin assignments see Table 7-1.

Table 7-1

RS-449 Connector Pin Assignments

PIN	CIRCUIT	449 DESCRIPTION	COMMENT
1	SHIELD	Ground	internally connected to 27, 37, 19, 30
2	SI	Signaling rate indicator	open
3	SPARE	Spare	open
4	SD (A)	Send Data	output
5	ST (A)	Send Timing	input
6	RD (A)	Receive Data	input
7	RS (A)	Request to Send	output
8	RT (A)	Receive Timing	input
9	CS (A)	Clear to Send	input
10	LL	Local Loopback	423 output tied OFF
11	DM (A)	Data Mode	input
12	TR (A)	Terminal Ready	422/423 output tied ON
13	RR (A)	Receiver Ready	input
14	RL	Remote Loopback	423 output tied OFF
15	IC	Incoming Call	open
16	SF/SR+	Select Frequency/ Signaling Rate Selector	423 output tied ON
17	TT (A)	Terminal Timing	output
18	TM	Test Mode	input
19	SG	Signal Ground	
20	RC	Receive Common	
21	SPARE	Spare	open

Table 7-1 (Cont.)

RS-449 Connector Pin Assignments

PIN	CIRCUIT	449 DESCRIPTION	COMMENT
22	SD (B)	Send Data	output
23	ST (B)	Send Timing	input
24	RD (B)	Receive Data	input
25	RS (B)	Request to Send	output
26	RT (B)	Receive Timing	input
27	CS (B)	Clear to Send	input
28	IS	Terminal in Service	423 output tied ON
29	DM (B)	Data Mode	input
30	TR (B)	Terminal Ready	output
31	RR (B)	Receiver Ready	input
32	SS	Select Standby	423 output tied OFF
33	SQ	Signal Quality	open
34	NS	New Signal	423 output tied OFF
35	TT (B)	Terminal Timing	output
36	SB	Standby Indicator	open
37	SC	Send Common	

7.3 RS-449 DTE/DCE INTERFACE MODULE (MODEL 40200)

7.3.1 Introduction

The RS-449 DTE/DCE Interface Module has been designed according to the Electronic Industries Association (EIA) Standard RS-449 (November 1977). This interface module enables a FIREBERD to act as data terminal equipment (DTE) for use in testing data communications equipment (DCE). With the use of a special adaptor cable (included) the FIREBERD can be configured as data communications equipment (DCE) (see Figure 7-2). The data is exchanged in a serial-binary format with a synchronous clock. The RS-449 Specification describes two categories of signals: Category 1 and Category 2. The specification allows Category-1 circuits to be implemented with either RS-422 (balanced) or RS-423 (unbalanced) drivers. All Category-2 circuits are specified to be the RS-423 type.

The RS-449 DTE/DCE Interface Module converts signals with characteristics specified by the RS-449 interface specification to the TTL signals used by the FIREBERD. The following sections provide a functional description of the RS-449 DTE/DCE Interface Module.

7.3.2 Functional Description - DTE Operation

In a typical RS-449 circuit, the DCE supplies timing to the DTE (FIREBERD) on the ST (Send Timing) leads. With the FIREBERD's GENERATOR CLOCK TX (RCV) switch in the EXT I/F position, the FIREBERD will generate SD (Send Data) and TT (Terminal Timing) coincident with the clock received on the ST leads (see Figure 7-3). With the FIREBERD's GENERATOR CLOCK TX (RCV) switch set for any of the internal rates (including FA, FB, FC, or FD if so equipped), the FIREBERD will ignore the ST leads and generate SD and TT coincident with the selected internal rate (see Figure 7-4). Data and clock are received on the RD (Receive Data) and RT (Receive Timing) leads for BER measurement.

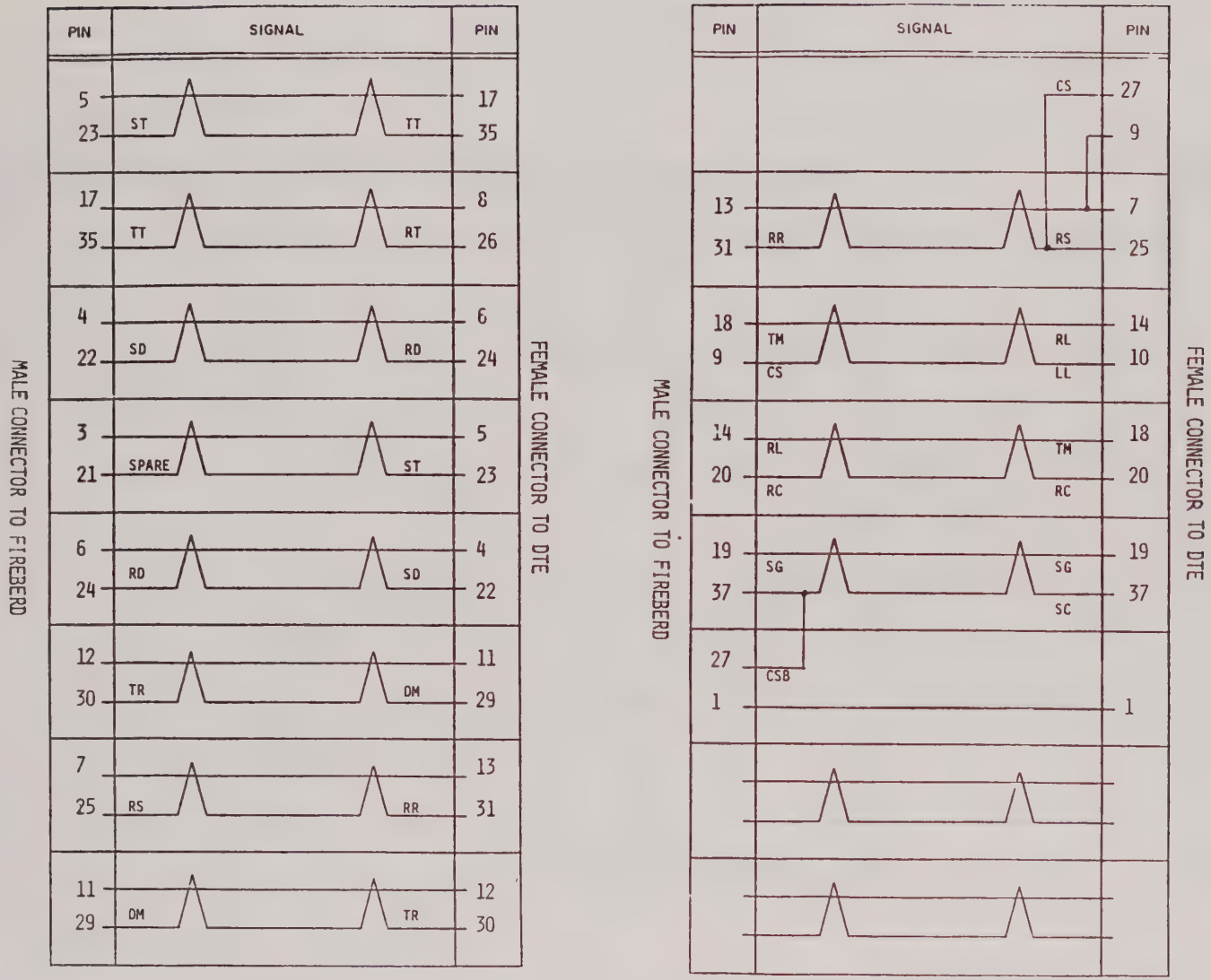


Figure 7-2

DCE Cable For RS-449 Interface

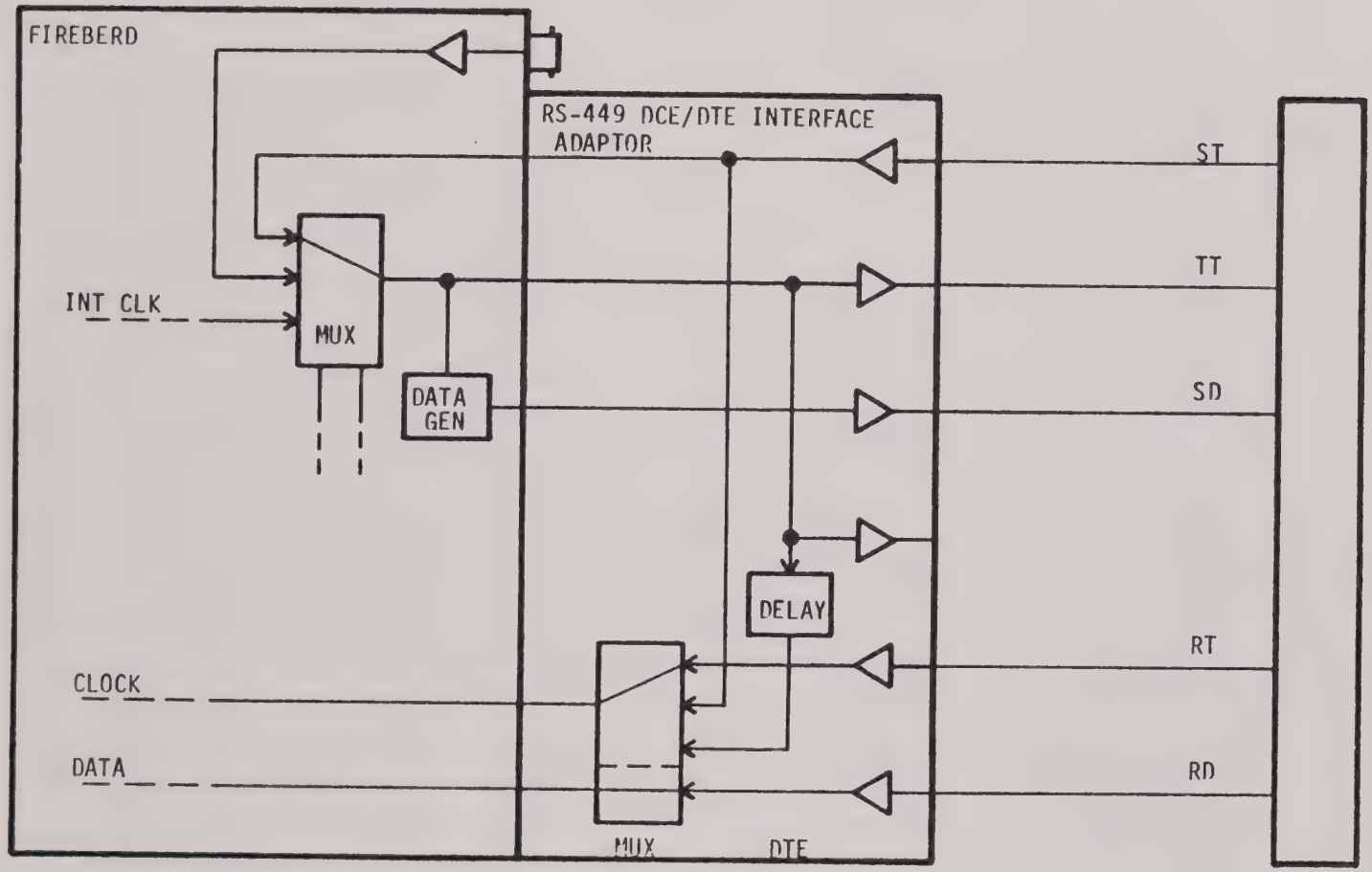


Figure 7-3. DTE-External Timing
INTERFACE: "DTE" POSITION
FIREBERD: "EXT/IF" POSITION

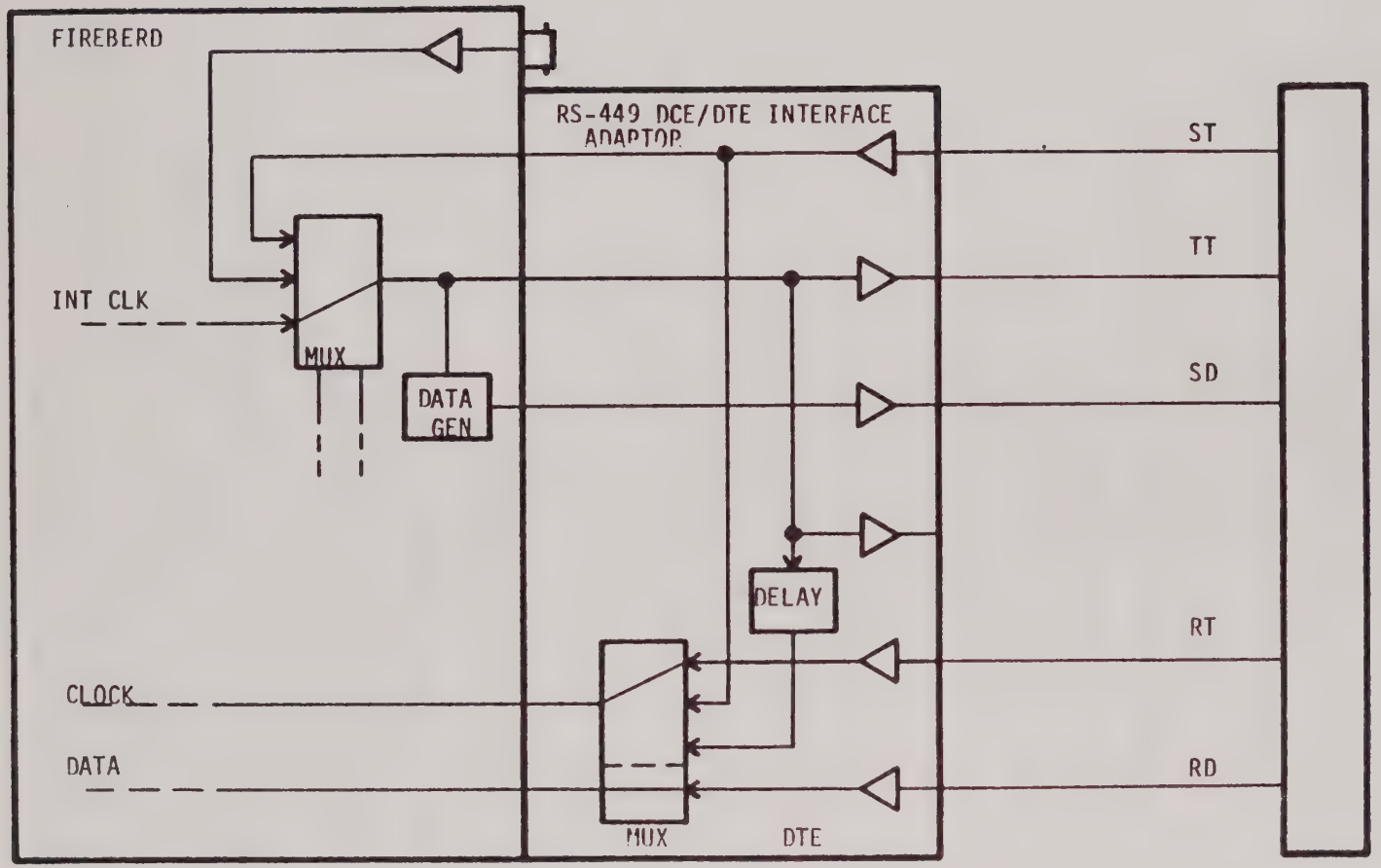


Figure 7-4. DTE-Internal Timing
(FIREBERD: "1.2, 2.4, 4.8, ..., F_C, F_D")

Two multi-function CLOCK INVERT/NORMAL switches are provided on the RS-449 DTE/DCE Interface Module's panel. As a DTE, setting the (RCV) TX INV switch to the INV (up) position causes SD to be valid on the rising edge of the selected clock source instead of the falling edge (Normal-middle position). By setting the (RCV) TX INV switch down, the transmit clock is unaffected and LL (Local Loopback) is turned on. As a DTE, setting the (RCV) TX INV switch to the INV (up) position causes FIREBERD to expect valid data (RD) on the rising edge of the RT clock instead of the falling edge (Normal-middle position). By setting the (RCV) TX INV switch down, the receive clock is unaffected and RL (Remote Loopback) is turned on.

A toggle switch on the FIREBERD front panel allows RS (Request to Send) to be turned on and off. CS (Clear to Send), RR (Receiver Ready), and DM (Data Mode) are received and their status displayed on the front panel of the FIREBERD.

A loop test switch is provided on the front panel of the FIREBERD which will, using relays, connect the transmit clock and data outputs to the receive clock and data inputs. User connections do not have to be removed during a loop test. External timing for the loop test can be provided on the ST leads (DCE source) or through the rear-panel BNC connector. The loop test function tests the actual drivers and receivers used during normal operation.

7.3.3 Functional Description - DCE Operation

The FIREBERD RS-449 DCE/DTE Interface Module can easily be configured to look like a DCE (data communications equipment) for testing of DTE (data terminal equipment) by using a special adaptor cable (included).

In a typical RS-449 circuit, the DCE (FIREBERD) supplies timing to the DTE on the ST (Send Timing) leads. The DTE will return to the DCE (FIREBERD), SD (Send Data), and TT (Terminal Timing). Two DCE modes are selectable on the interface panel: DCE TT and DCE ST. In the DCE TT position (see Figure 7-5), SD and TT are sent to the receive section of the FIREBERD for BER measurement. In the DCE ST position (see Figure 7-6) SD and the internally generated ST are sent to the receive section of the

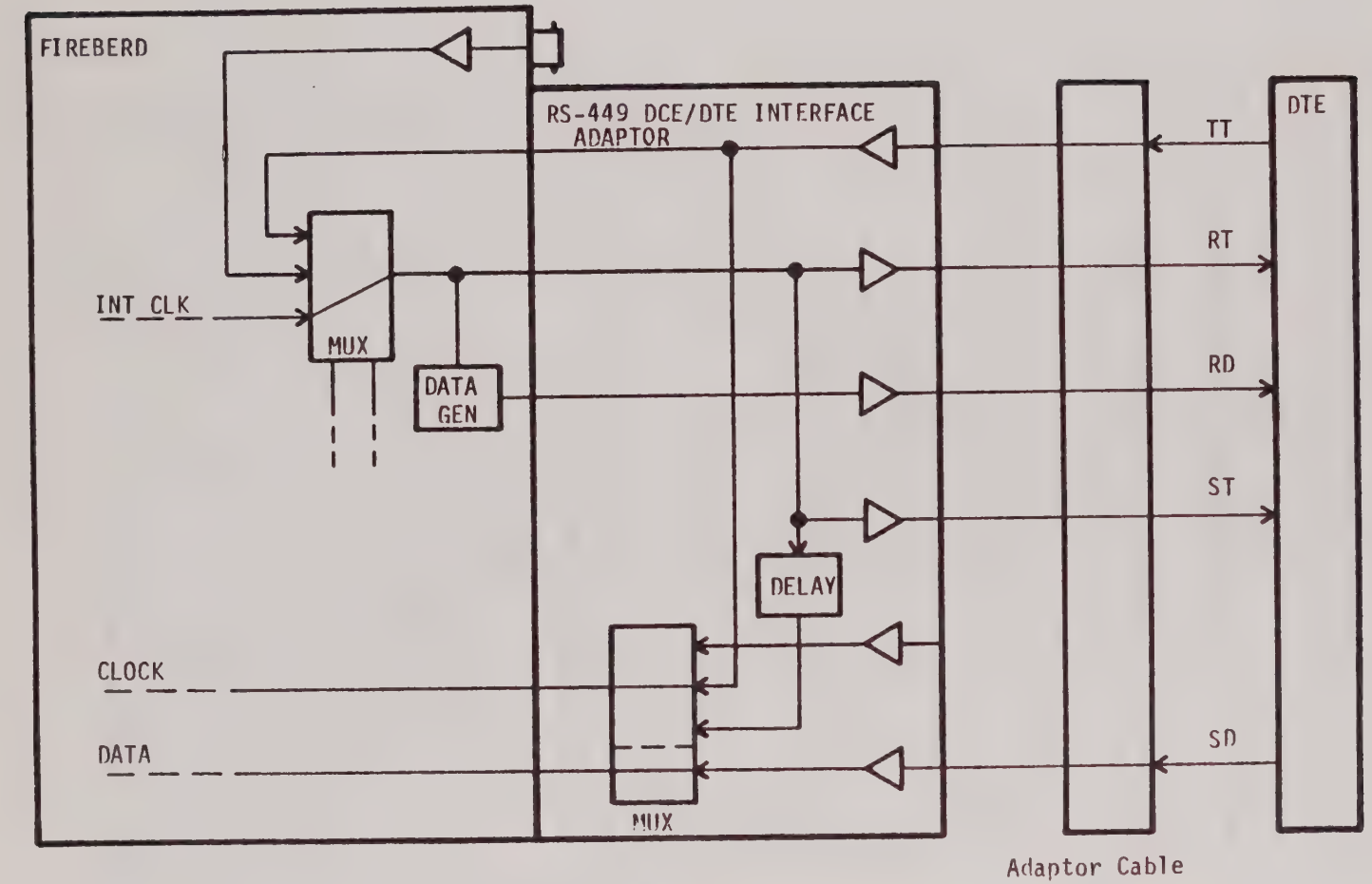


Figure 7-5. DCE-TT
INTERFACE: "DCE (TT)" POSITION
FIREBERD: "1.2, 2.4, 4.8, ..., F_C, F_D"

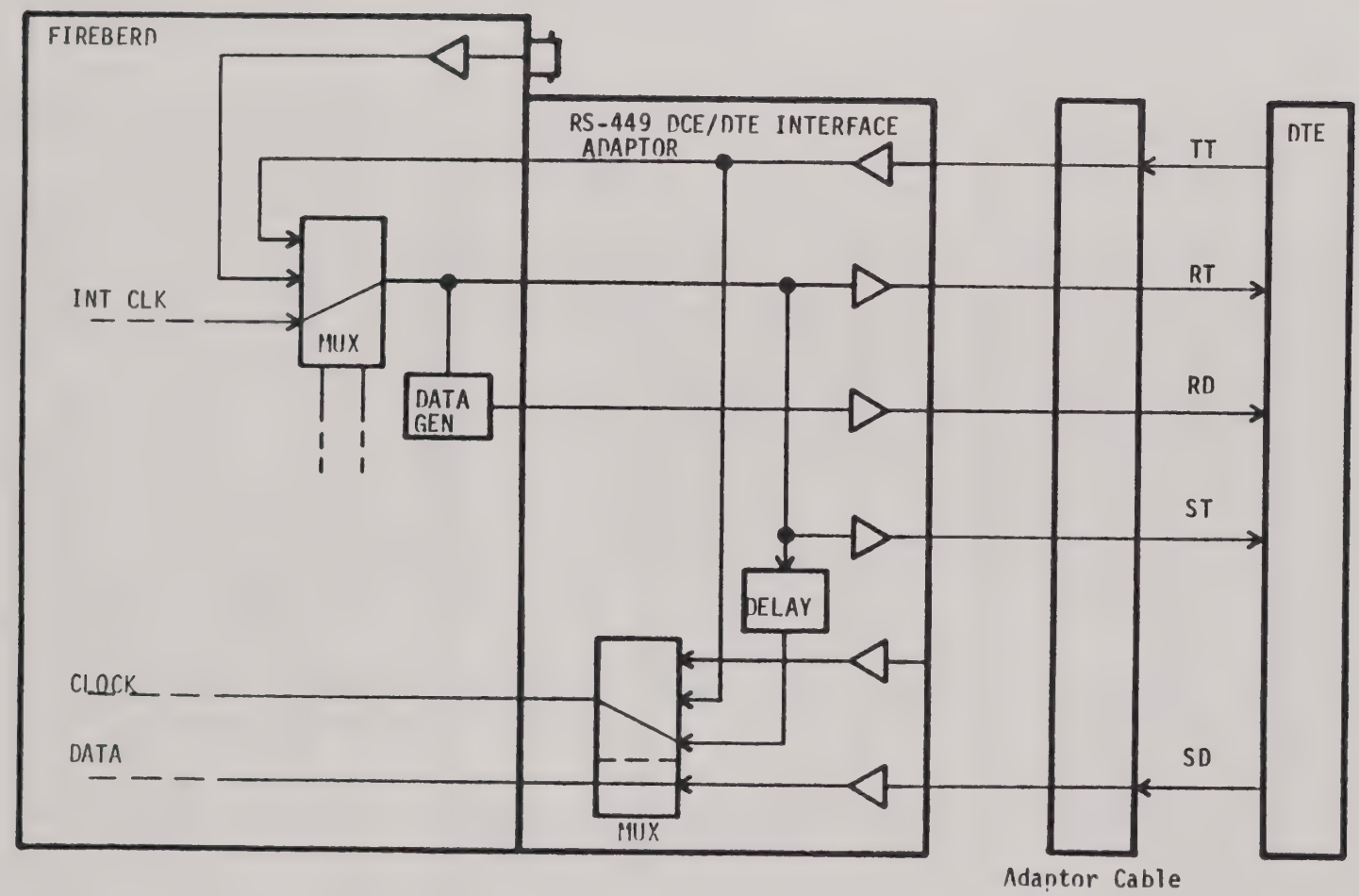


Figure 7-6. DCE-ST

INTERFACE: "DCE (ST)" POSITION

FIREBERD: "1.2, 2.4, 4.8, ..., F_C, F_D"

FIREBERD for BER measurement. With the FIREBERD's GENERATOR CLOCK TX (RCV) switch set to the EXT I/F position, RD (Receive Data), and RT (Receive Timing) will be generated coincident with TT (Terminal Timing) from the DTE (this assumes the DTE can generate TT independent of ST). With the GENERATOR CLOCK TX (RCV) switch set to EXT BNC or to any of the internal rates (including FA, FB, FC, or FD, if so equipped) the FIREBERD will generate RD and RT coincident with the supplied clock or the chosen internal rate.

Two clock invert switches are provided on the RS-449 DTE/DCE Interface Module's panel. All DCE functions are shown in parenthesis on the interface panel. As a DCE, the TRANSMIT INVERT switch provides two functions. Setting the TRANSMIT INVERT switch up causes FIREBERD to expect valid SD (Send Data) on the rising edge of the selected clock source instead of the falling edge (Normal-middle position). Setting the TRANSMIT INVERT switch down turns on TM (Test Mode) with no inversion of the clock. Setting the RECEIVE INVERT switch up causes FIREBERD to generate a valid RD on the rising edge of RT instead of the falling edge (Normal-middle position). As a DCE the RECEIVE INVERT switch has no secondary function.

At the DTE end of the adaptor cable, CS (Clear to Send) is tied directly to RS (Request to Send). A toggle switch on the front panel of the FIREBERD allows RR (Receiver Ready) to be turned on and off. TR (Terminal Ready), RS (Request to Send), and LL (Local Loopback) are received and their status displayed on the front panel of the FIREBERD.

The LOOP position of the TEST switch on the front panel of the FIREBERD will, using relays, connect the clock and data drivers to the clock and data receivers. User connections do not have to be removed during a loop test. During a loop test, the ST driver still sends timing to the DTE. Timing for the loop test can be internally generated or, in the EXT I/F or EXT BNC positions, be received on the TT leads or the rear-panel BNC connector. The loop-test function tests actual drivers and receivers that are used during normal operation.

7.3.4 FIREBERD Test Points - DTE Operation

This section describes the relationship between the signals present at the interface module connector and the signals present at the FIREBERD rear-panel test points when DTE operation is specified.

RCV DATA/TX DATA: The voltage at this test point is greater than 2.5 volts when the Receive Data (RD) is a Mark and is less than 0.4 volts when RD is a Space.

RCV TIMING/-: When the RCV CLK switch is in the NORMAL position, the voltage at this test point is greater than 2.5 volts when the Receive Timing (RT) signal is in the ON condition and is less than 0.4 volts when RT is in the OFF condition. When the RCV CLK switch is in the INV position, the voltage at the test point is greater than 2.5 volts when the RT signal is in the OFF condition and is less than 0.4 volts when the RT signal is in the ON condition.

TX DATA/RCV DATA: The voltage at this test point will be greater than 2.5 volts when the Send Data (SD) signal is a Mark and is less than 0.4 volts when the SD signal is a Space.

SEND TIMING/TERM TIMING: The voltage at this test point will be greater than 2.5 volts when the Send Timing (ST) signal is in the ON condition and will be less than 0.4 volts when the ST signal is in the OFF condition. Use of the TX CLK NORMAL/INVERT switch will not affect these relationships.

TERM TIMING/RCV TIMING: This test point will be greater than 2.5 volts when the Terminal Timing (TT) signal is in the ON condition and will be less than 0.4 volts when TT is in the OFF condition.

7.3.5 FIREBERD Test Points - DCE Operation

This section describes the relationship between the signals present at the interface module connector and the signals present at the FIREBERD rear-panel test points when DCE operation is specified.

RCV DATA/TX DATA: The voltage at this test point will be greater than 2.5 volts when the Send Data (SD) signal is a Mark and will be less than 0.4 volts when the SD signal is a Space.

RCV TIMING/-: No signal will be present at this test point.

TX DATA/RCV DATA: The voltage at this test point will be greater than 2.5 volts when the Receive Data (RD) signal is a Mark and will be less than 0.4 volts when the RD signal is a Space.

SEND TIMING/TERM TIMIMG: The voltage at this test point will be greater than 2.5 volts when the Terminal Timing (TT) signal is in the ON position and will be less than 0.4 volts when TT is in the OFF position. Use of either CLK NORMAL/INVERT switch will not affect this relationship.

TERM TIMING/RCV TIMING: The voltage at this test point will be greater than 2.5 volts when the Receive Timing (RT) signal is in the ON condition and will be less than 0.4 volts when RT is in the OFF condition. Use of either CLK NORMAL/INVERT switch will not affect this relationship.

7.3.6 Specifications

RS-449 Category-1 Circuits (RS-423/RS422 TERM/RS-422 UNTERM):

Send Data (SD)
Receive Data (RD)
Terminal Timing (TT)

Send Timing (ST)
Receive Timing (RT)
Request to Send (RS)
Clear to Send (CS)
Receiver Ready (RR)
Terminal Ready (TR)
Data Mode (DM)

RS-449 Category-2 Circuits (RS-423 only):
Local Loopback (LL)
Remote Loopback (RL)
Test Mode (TM)

RS-422 Data Mark (binary 1), Control Lead OFF:
Lead (A) more negative than Lead (B).

RS-422 Data Space (binary 0), Control Lead ON:
Lead (A) more positive than Lead (B).

RS-423 Data Mark (binary 1), Control Lead OFF:
Negative polarity.

RS-423 Data Space (binary 0), Control Lead ON:
Positive polarity.

RS-422 Line Drivers:
Output differential voltage: 2.0 volts minimum.
Short circuit current: 150 mA maximum.
Output rise time: 20 nsec maximum.

RS-423 Line Drivers
Output voltage: $\pm$ 3.5 volts minimum.
Short circuit current: 150 mA maximum.
Output rise time: 1 microsecond typical (Model 40200-01).
4 microsecond typical (Model 40200-02).

RS-422 Terminated Line Receivers:

Load impedance: 100 ohms ± 10%.

Differential input threshold voltage: ± 0.25 volts.

RS-422 Unterminated Line Receivers:

Load impedance: 2000 ohms minimum.

Differential input threshold voltage: ± 0.25 volts.

RS-423 Receivers:

Load impedance: 2000 ohms minimum.

Input threshold voltage: ± 0.25 volts.

For connector pin assignments see Table 7-2.

Table 7-2

RS-449 DTE/DCE Interface Adaptor

Connector Pin Assignments

PIN	CIRCUIT	449 DESCRIPTION	COMMENT*
1	SHIELD	Ground	internally connected to 20, 37, 19
2	SI	Signaling Rate Indicator	open
3	SPARE	Spare	ST (DCE only)
4	SD (A)	Send Data	output
5	ST (A)	Send Timing	input
6	RD (A)	Receive Data	input
7	RS (A)	Request to Send	output
8	RT (A)	Receive Timing	input
9	CS (A)	Clear to Send	input
10	LL	Local Loopback	423 output
11	DM (A)	Data Mode	input
12	TR (A)	Terminal Ready	output - tied ON
13	RR (A)	Receiver Ready	input
14	RL	Remote Loopback	423 output
15	IC	Incoming Call	open
16	SF/SR	Select Frequency/ Signaling Rate Selector	open
17	TT (A)	Terminal Timing	output
18	TM	Test Mode	input
19	SG	Signal Ground	
20	RC	Receive Common	
21	SPARE	Spare	ST (DCE only)

* Comments refer to the interface-panel connector and are applicable to DTE operation only.

Table 7-2 (Cont.)

RS-449 DTE/DCE Interface Adaptor

Connector Pin Assignments

PIN	CIRCUIT	449 DESCRIPTION	COMMENT
22	SD (B)	Send Data	output
23	ST (B)	Send Timing	input
24	RD (B)	Receive Data	input
25	RS (B)	Request to Send	output
26	RT (B)	Receive Timing	input
27	CS (B)	Clear to Send	input
28	IS	Terminal in Service	open
29	DM (B)	Data Mode	input
30	TR (B)	Terminal Ready	output - tied ON
31	RR (B)	Receiver Ready	input
32	SS	Select Standby	open
33	SQ	Signal Quality	open
34	NS	New Signal	open
35	TT (B)	Terminal Timing	output
36	SB	Standby Indicator	open
37	SC	Send Common	

7.4 V.35/306 DTE INTERFACE MODULE (MODEL 40138)

7.4.1 Introduction

The V.35/306 Interface Module is designed to meet the following interface specifications:

1. CCITT Recommendation V.35.

2. 306-Type Wideband Data Set. Bell System Technical Reference PUB 41304.

3. Digital Data System Data Service Unit. Bell System Technical Reference PUB 41450.

This interface module enables a FIREBERD to act as data terminal equipment (DTE) for use in testing data communications equipment (DCE). The data is exchanged in serial-binary format with a synchronous clock. The following sections provide functional, switch, test point, and specification descriptions.

7.4.2 Functional Description

The V.35/306 Interface Module converts between the signal characteristics specified by the appropriate interface specifications and the TTL signals used by FIREBERD.

When the unit is used in a 306-type system, the DCE supplies timing to the FIREBERD on the SCT lead. This signal is selected by the EXT I/F position of the GENERATOR CLOCK TX (RCV) switch on the FIREBERD front panel. The selected clock is used to generate Send Data (SD) and Serial Clock Transmit External (SCTE), which are sent back to the DCE. Alternatively, SD and SCTE may be generated from timing supplied through the rear-panel BNC input or one of the internal rates.

When the unit is used in a V.35 or Data Service Unit (DSU) System, timing is supplied to the FIREBERD in the same manner as 306-type systems. However, some V.35 and DSU

systems do not accept the SCTE signal from the FIREBERD. The maximum operating speed is limited in this operating mode due to the cable delay and the 70 nsec delay between the incoming SCT signal and the out-going SD signal.

Two high-speed balanced V.35 drivers are provided for the Send Data and SCTE outputs. Two other drivers, Request to Send (RTS) and Data Terminal Ready (DTR) are designed according to RS-232C and CCITT V.28 specifications. The RTS output is controlled by a FIREBERD front-panel switch. The DTR output is tied high on this interface module. There are three high-speed balanced V.35-type receivers provided for the Serial Clock Transmit (SCT), Receive Data (RD), and the Serial Clock Receive (SCR). The SCT signal is sent to the transmit section of the FIREBERD where it may be selected for use by the GENERATOR CLOCK TX (RCV) switch. Receive Data (RD) and the Serial Clock Receive (SCR) signals are sent to the receiver section of the FIREBERD for error analysis. Three other receivers, Data Set Ready (DSR), Clear to Send (CTS), and Receive Line Signal Detector (RLSD) directly drive the FIREBERD front-panel indicators. These receivers are designed according to the RS-232C and CCITT V.28 specifications.

Also included in the interface module is a loop-test relay designed to connect the transmit clock and data outputs to the receive clock and data inputs when the FIREBERD LOOP TEST switch is in the LOOP position. This relay will also disconnect the drivers and receivers from the interface connector. Loop test does not affect the TX TIMING IN (SCT) signal.

7.4.3 Data-Clock Test Points

This section describes the relationship between the data and clock signals at the interface connector and the FIREBERD test points when the V.35/306 Interface Module is in use.

RCV DATA/RX DATA

The signal at this test point is greater than 2.5 volts when the received data at the RD input of the interface module is a differential voltage with the B input being more positive than the A input (Mark). The RCV DATA Test Point is less than .4 volts when the received data at RD is a differential voltage such that the A input is more positive than the B input (space).

RCV TIMING/-

This test point provides a TTL signal, equivalent to the received clock (SCR) at the input to the V.35/306 Interface Module. With the RCV CLK polarity switch in the normal position, the signal at this test point is greater than 2.5 volts when the received clock signal at the SCR input to the interface module is a differential voltage such that the A input is greater than the B input. A voltage of less than 0.4 volts at this test point is present when the A input is less positive than the B. With the RCV CLK (SCR) switch in the INV position the signal at this test point will be inverted to that signal at the interface module input.

TX DATA/RCV DATA

This test point provides the TTL equivalent of the signal at the Send Data (SD) output of the interface module. The signal at this test point is greater than 2.5 volts when the differential voltage at the Send Data outputs are such that the B output is more positive than the A output (Mark). The test point signal is less than 0.4 volts when the differential voltage at the Send Data output consists of the A output being more positive than the B output (Space).

SEND TIMING/TERM TIMING

This test point provides a TTL signal equivalent to the signal at the Serial Clock Transmit (SCT) inputs at the interface module. The signal at this test point is greater than 2.5 volts when the A input at the interface is more positive than the B input. The test-point signal is less than 0.4 volts when the B input is more positive than the A input.

TERM TIMING/RCV TIMING

The signal at this test point is the TTL equivalent of the signal at the Serial Clock Transmit External (SCTE) output of the interface module. The signal at the test point is greater than 2.5 volts when the differential voltage at SCTE is such that the A output is more positive than the B output. The test point is less than 0.4 volts when the B output is more positive than the A output.

CLOCK-DATA PHASE RELATIONSHIP

With the clock invert switches in the NORMAL position the receive clock-data phase relationship at the receive clock and data test points will be the same as that at SCR and RD inputs to the V.35/306 Interface Module. The transmit clock and data test points will have the same phase relationship as the SCTE, SCT, and SD outputs at the interface module, independent of the TX CLK POLARITY switch.

With the RCV CLK (SCR) switch in the INVERT position the clock-data phase relationship at the receive clock and data test points will be inverted to that input at the interface module.

7.4.4 Switch and Indicator Description

RCV CLK (SCR)

The RCV CLK (SCR) switch controls the polarity of the received clock signal (SCR) as it enters the FIREBERD from the V.35/306 Interface Module. In the NORM position, the data (RD) - clock (SCR) phasing is accepted according to the interface specifications. The INVERT position allows the FIREBERD to accept data and clock phasing inverted with respect to the interface specifications.

TX CLK SCTE AND SCT

The TX CLK SCTE and SCT switch controls the polarity of the clock used to develop the transmit clock and data functions inside the FIREBERD. The NORM position transmits the data-clock phasing at the interface as stated in the interface specifications. In the INVERT position, the transmit clock is phase inverted with respect to the specifications.

NON STANDARD TIMING

This indicator will illuminate when either or both clock invert switches are in the INVERT position.

7.4.5 Specifications

General:	Maximum speed: 13 MHz typical. Delay SCT to SD: approximately 70 ns. Skew SCTE to SD: approximately 15 ns.
Balanced Drivers:	Signal swing (Bipolar): ± .55 volts ± .1v into 100 ohms. Short circuit current: less than 100 mA. Rise Time: less than 20 nsec. Generator Impedance: 100 ohms.
Balanced Receivers:	Load resistance: 100 ohms.
Unbalanced Drivers: (RS-232)	Rise time: greater than 20 microseconds. Generator Impedance: less than 100 ohms. Short circuit current: less than 100 mA.
Unbalanced Receivers: (RS-232)	Load Impedance: 3K to 7K ohms. Maximum input voltage: ± 25 volts.

For connector pin assignments see Table 7-3.

Table 7-3

V.35/306 Connector Pin Assignments

PIN	CIRCUIT	V.35/306 DESCRIPTION	COMMENT
A	AA	Protective Ground	internally connected to B
B	AB	Signal Ground	internally connected to A
C	CA	Request to Send	output
D	CB	Clear to Send	input
E	CC	Data Set Ready	input
F	CF	Received Line Signal Detector	input
H	CD	Data Terminal Ready	output - tied ON
J	CE	Ring Indicator	open
K	--	Local Test	open
R	RD (A)	Received Data	input
T	RD (B)	Received Data	input
V	SCR (A)	Serial Clock Receive	input
X	SCR (B)	Serial Clock Receive	input
P	SD (A)	Send Data	output
S	SD (B)	Send Data	output
U	SCTE (A)	Serial Clock Transmit External	output
W	SCTE (B)	Serial Clock Transmit External	output
Y	SCT (A)	Serial Clock Transmit	input
AA or a	SCT (B)	Serial Clock Transmit	input

7.5 V.35/306 DTE/DCE INTERFACE MODULE (MODEL 40202)

7.5.1 Introduction

The V.35/306 DTE/DCE Interface Module is designed in accordance with the following interface specifications:

- o CCITT Recommendation V.35
- o 306-Type Wideband Data Set. Bell System Technical Reference PUB 41304
- o Digital Data System Data Service Unit. Bell System Technical Reference PUB 41450.

This interface enables a FIREBERD to act as data terminal equipment (DTE) for use in testing data communications equipment (DCE). With the use of a special adaptor cable (included) the FIREBERD can be configured as data communications equipment (DCE) for testing data terminal equipment (DTE) (see Figure 7-7). The data is exchanged in serial-binary format with a synchronous clock. The following sections provide specifications and functional descriptions.

7.5.2 Functional Description - DTE Operation

The V.35/306 DTE/DCE Interface Module converts the signal characteristics specified by the appropriate interface specifications to the TTL signals used by the FIREBERD.

In a 306-type system, the DCE supplies timing to the DTE (FIREBERD) on the SCT (Serial Clock Transmit) leads. With the FIREBERD's GENERATOR CLOCK TX (RCV) switch in the EXT I/F position, the FIREBERD will generate SD (Send Data) and SCTE (Serial Clock Transmit External) coincident with the clock received on the SCT leads (see Figure 7-8). With the FIREBERD's GENERATOR CLOCK TX (RCV) switch set to any of the internal rates (including FA, FB, FC, or FD if so equipped), the FIREBERD will ignore the SCT leads and generate SD and SCTE coincident with the selected internal rate.

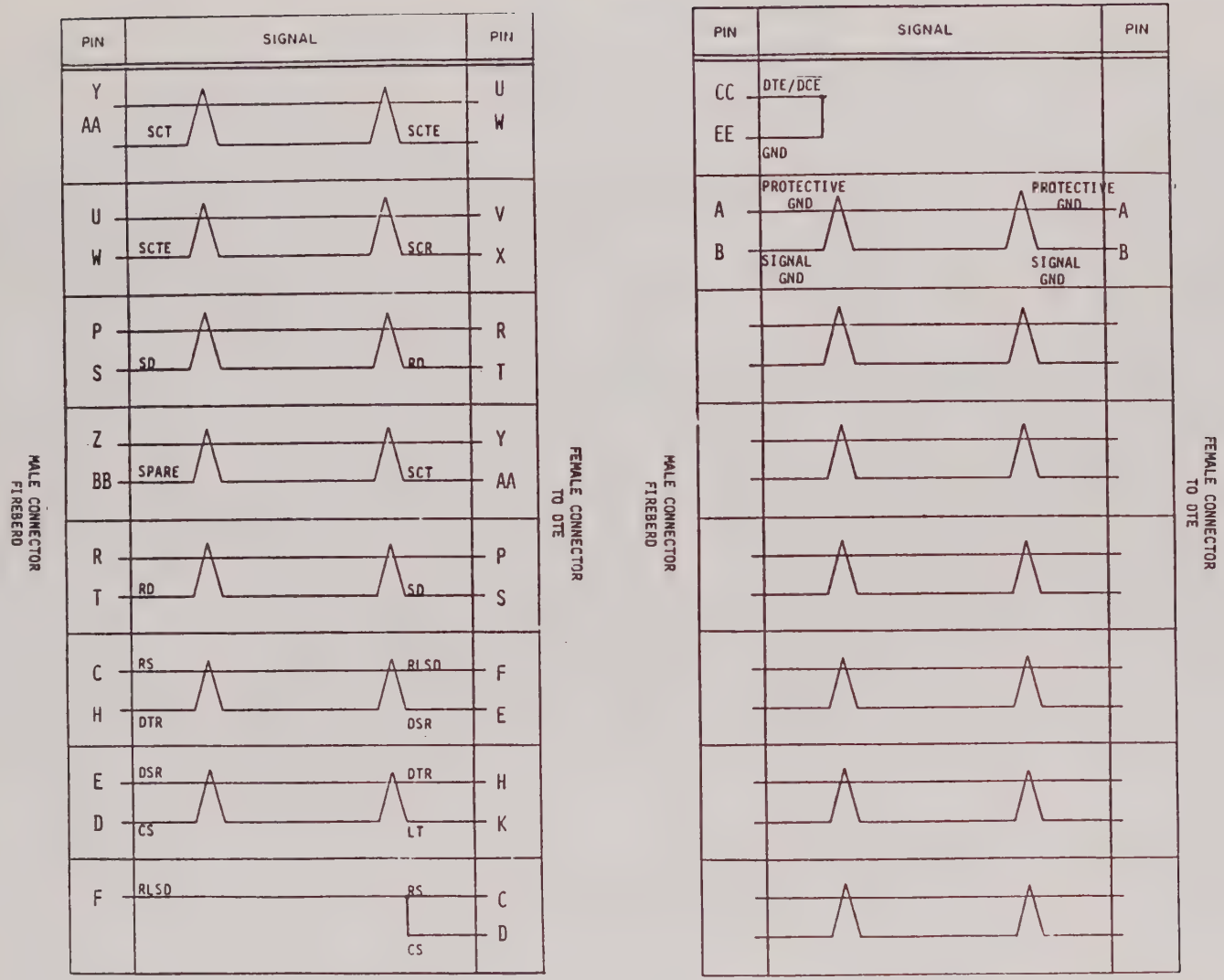


Figure 7-7

V.35/306 DTE to DCE Adaptor Cable FIREBERD

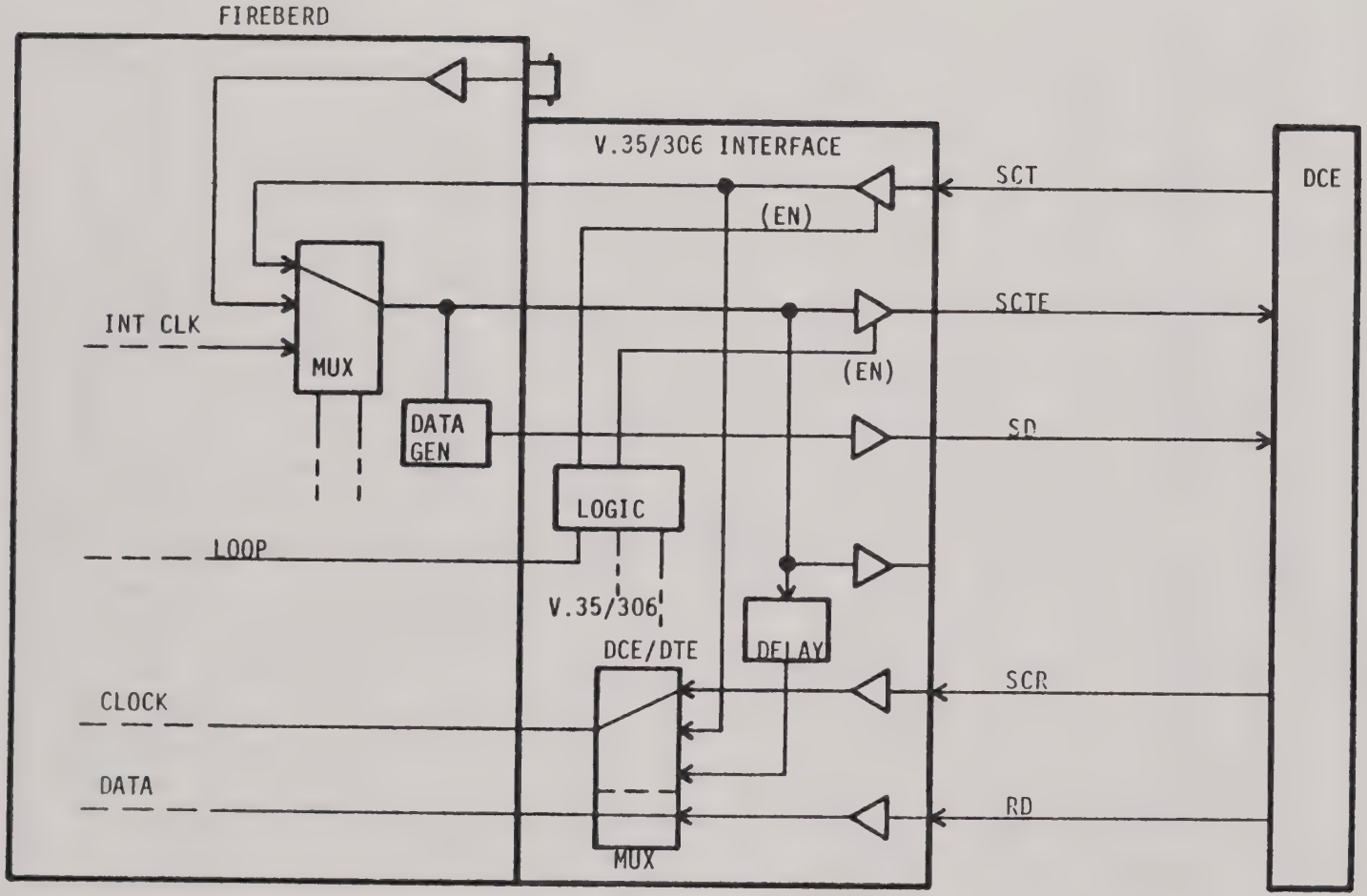


Figure 7-8. 306 DTE

INTERFACE: "306" POSITION

FIREBERD: "EXT I/F" POSITION

In a V.35 or Data Service Unit (DSU) type system, timing is supplied to the FIREBERD on the SCT leads in the same manner as the 306-type system. However, the V.35- and DSU-type systems do not accept the SCTE signal from the FIREBERD. With the FIREBERD interface set for V.35 operation, the SCTE driver is disabled and the GENERATOR CLOCK TX (RCV) switch should be set to the EXT I/F position. (With an internal clock chosen, data only will appear at the interface connector). In both the V.35 and 306 modes, data and clock are received for BER measurement on the RD (Receive Data) and the SCR (Serial Clock Receive) leads.

Two clock switches are provided on the V.35/306 DTE/DCE Interface Module panel. As a DTE, setting the TRANSMIT CLOCK switch to the INVERT position causes SD (Send Data) to be valid on the rising edge of the chosen clock source instead of the falling edge (Normal) (see Figure 7-9). Setting the RECEIVE CLOCK switch to the INVERT position causes the FIREBERD to expect valid data (RD) on the rising edge of the SCR Clock instead of the falling edge (Normal). If either of the clock invert switches are set to the INVERT position, a NON-STANDARD TIMING indicator becomes illuminated.

All clock and data drivers and receivers are high speed balanced V.35 type (see Figure 7-10). All signaling drivers and receivers are single-ended RS-232 (CCITT V.28) type. RS (Request to Send) is controlled by a FIREBERD front-panel switch. DSR (Data Set Ready), RLSD (Receive Line Signal Detect), and CS (Clear to Send) are received and their status displayed on the front panel of the FIREBERD (see Figure 7-11).

A LOOP TEST switch is provided on the front panel of the FIREBERD which will, in the LOOP position, connect the transmit clock and data outputs to the receive clock and data inputs. User connections do not have to be removed during a loop test. External timing for the loop test can be provided on the SCT leads (DCE Source) or through the rear-panel BNC Connector. The loop-test functions tests actual drivers and receivers that are used during normal operation.

7.5.3 Functional Description - DCE Operation

The V.35/306 DTE/DCE Interface Module can easily be configured to look like DCE (data communications equipment) for testing of DTE (data terminal equipment) by using a special adaptor cable (included). When the special adaptor cable is connected to the interface, configuration as a DCE is done automatically.

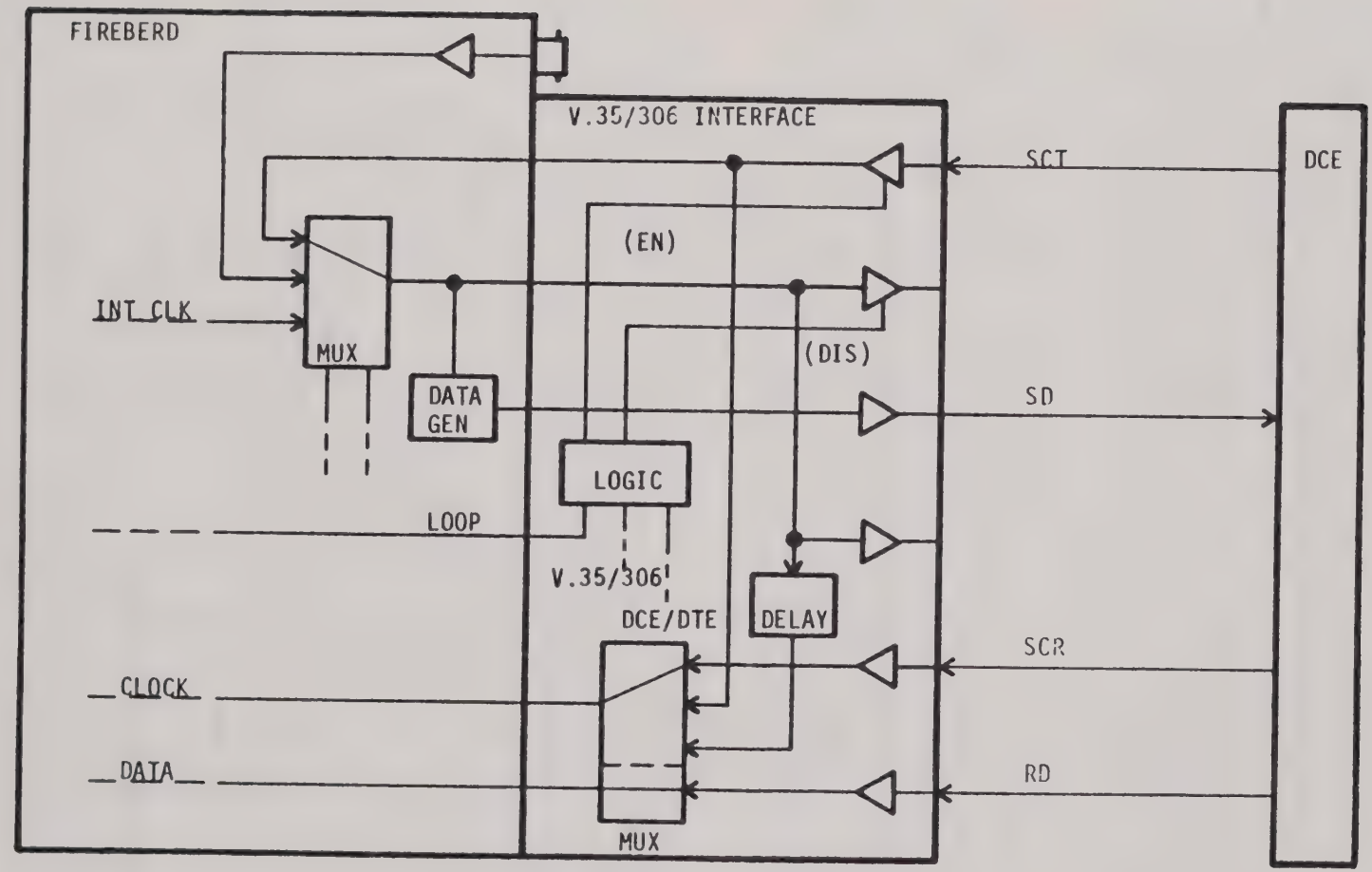


Figure 7-9. V.35 DTE
INTERFACE: "V.35" POSITION
FIREBERD: "EXT I/F" POSITION

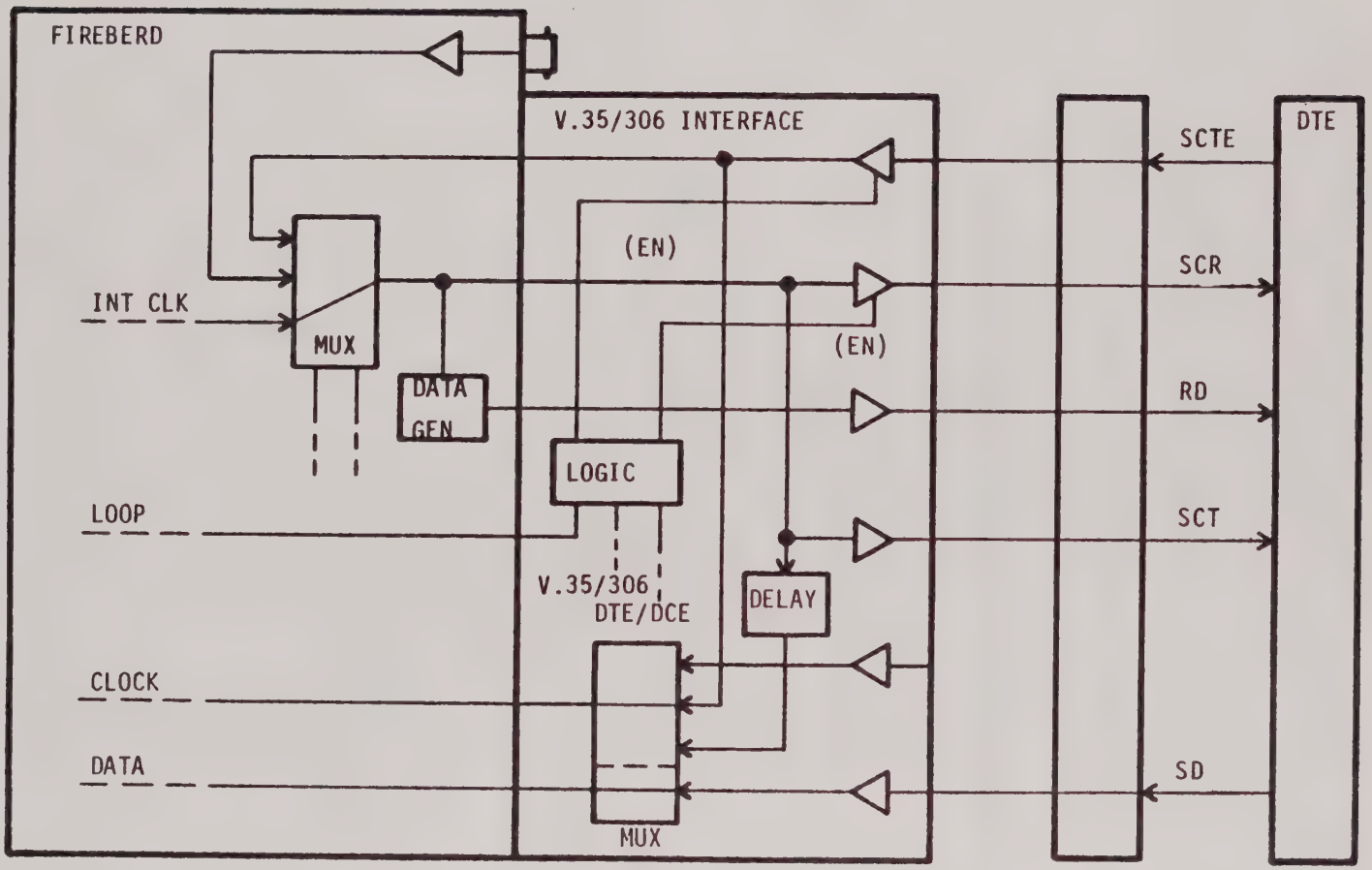


Figure 7-10. 306 DCE
INTERFACE: "306" POSITION
FIREBERD: "1.2, 2.4, 4.8, ..., F_C, F_D"

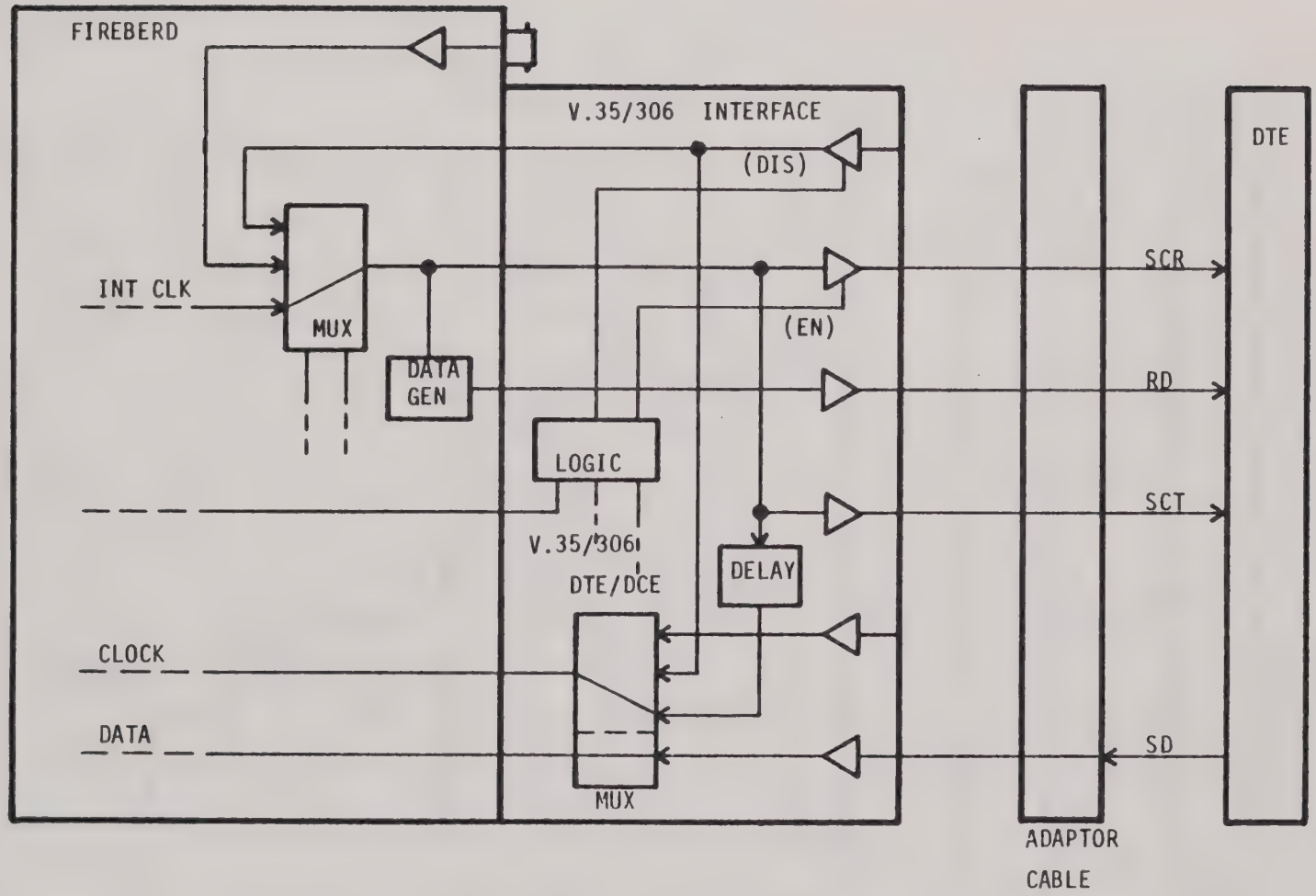


Figure 7-11. V.35 DCE

INTERFACE: "V.35" POSITION

FIREBERD: "1.2, 2.4, 4.8, ..., F_C, F_D"

In a 306-type system, the DCE (FIREBERD) supplies timing to the DTE on the SCT (Serial Clock Transmit) leads. The DTE will return to the DCE (FIREBERD), SD (Send Data), and SCTE (Serial Clock Transmit External) which may or may not be coincident with the clock on the SCT leads (Depending upon the configuration of the DTE). The SD and SCTE signals are sent to the receive section of the FIREBERD for error analysis.

In a V.35 or Data Service Unit (DSU) type system, SCT (Serial Clock Transmit) is generated in the DCE (FIREBERD) as in the 306-type system (see Figure 7-10). However, the DTE will not return timing on the SCTE (Serial Clock Transmit External) leads. The DTE returns only SD (Send Data) to the DCE (FIREBERD) coincident with the DCE-generated SCT. In the V.35 mode, the SCTE receiver is disabled, and the SD and SCT signals are sent to the receive section of the FIREBERD for error analysis. In both the V.35 and 306 modes, the FIREBERD as a DCE generates SCR (Serial Clock Receive) and RD (Receive Data) and sends them to the DTE.

All clock and data drivers and receivers are high-speed balanced V.35 type. All signaling drivers and receivers are single-ended RS-232 (CCITT V.28) type. A toggle switch on the front panel of the FIREBERD allows RLSD (Receive Line Signal Detect) to be turned ON and OFF in the DCE mode (see Figure 7-11). DTR (Data Terminal Ready), RS (Request to Send), and LT (Local Test) are received and their status displayed on the FIREBERD front panel. The DTE generated RS (Request to Send) is tied directly back to the DTE received CS (Clear to Send).

Two clock switches are provided on V.35/306 DTE/DCE Interface Module panels. As a DCE, setting the RCV CLK switch to the INVERT position causes the FIREBERD to generate a valid RD (Receive Data) on the rising edge of SCR (Serial Clock Receive). Setting the TX CLK switch to the INVERT position causes the FIREBERD to expect valid SD (Send Data) on the rising edge of the SCTE (Serial Clock Transmit External) for 306 Mode or SCT (Serial Clock Transmit) if the V.35 mode is chosen. If either of the clock switches are set to the INVERT position, a NON-STANDARD TIMING indicator becomes illuminated.

When the TEST switch on the front panel of the FIREBERD is in the LOOP position, this interface, using relays, connects the transmit clock and data outputs to the receive clock and data inputs. User connections do not have to be removed to perform a loop test. External

timing can be provided for the loop test on the SCTE leads (306 mode only) or through rear-panel BNC connector. The loop-test function tests the actual drivers and receivers t are used during normal operation.

7.5.4 Data/Clock Test Points - DTE Operation

This section describes the relationship between the signals at the interface connector the signals at the FIREBERD rear-panel test points when the FIREBERD is used as a DTE.

RCV DATA/TX DATA

The signal at this test point will be greater than 2.5 volts when the data at the Rece Data (RD) leads is a Mark and will be less than 0.4 volts when RD is a Space.

RCV TIMING/-

With the RCV CLK polarity switch in the NORMAL position, the signal at this test po will be greater than 2.5 volts when the (A) input of the SCR signal is more positive than the input (ON). The signal at the test point will be less than 0.4 volts when the (A) input is m negative than the (B) input (OFF). Placing the RCV CLK polarity switch in the INVE position inverts the test point/interface connector-phase relationship.

TX DATA/RCV DATA

The signal at this test point will be greater than 2.5 volts when the data at the Send D (SD) leads is a Mark and will be less than 0.4 volts when SD is a Space.

SEND TIMING/TERM TIMING

The signal at this test point will be greater than 2.5 volts when the (A) input of the S signal is more positive than the (B) input (ON). The test point will be less than 0.4 volts wh the (A) input of SCT is more negative than the (B) input (OFF). Use of the TX CLK polar switch will not affect this relationship.

7.5.5 Data/Clock Test Points - DCE Operation

This section describes the relationship between the signals at the interface connector and the signals at the FIREBERD rear-panel test points when the FIREBERD is used as a DCE.

RCV DATA/TX DATA

The signal at this test point will be greater than 2.5 volts when the Send Data (SD) signal is a Mark and will be less than 0.4 volts when SD is a Space.

TX DATA/RCV DATA

The signal at this test point will be greater than 2.5 volts when the Receive Data (RD) signal is a Mark and will be less than 0.4 volts when RD is a Space.

SEND TIMING/TERM TIMING

The signal at this test point will be greater than 2.5 volts when the (A) lead of the SCTE signal is more positive than the (B) lead. Use of the TX CLK polarity switch will not affect this relationship.

TERM TIMING/RCV TIMING

The signal at this test point will be greater than 2.5 volts when the (A) lead of the SCR signal is more positive than the (B) lead. The test point will be less than 0.4 volts when the (A) lead of SCR is more negative than the (B) lead. Use of the RCV CLK polarity switch will not affect this relationship.

For connector pin assignments see Tables 7-4 and 7-5.

7.5.6 Specifications

General:

Maximum speed (306 mode): 13 MHz.
Maximum speed (V.35 mode): Cable length dependent.
Delay SCT to SD: approximately 70 nsec typical.
Skew SCTE to SD: approximately 20 nsec typical.

Table 7-4

V.35/306 DTE/DCE Connector Pin Assignments

PIN	CIRCUIT	V.35/306 DESCRIPTION	COMMENT*
A	AA	Protective Ground	internally connected to B
B	AB	Signal Ground	internally connected to A
C	CA	Request to Send	output
D	CB	Clear to Send	input
E	CC	Data Set Ready	input
F	CF	Received Line Signal Detector	input
H	CD	Data Terminal Ready	output - tied ON
J	CE	Ring Indicator	open
K	--	Local Test	open
R	RD (A)	Received Data	input
T	RD (B)	Received Data	input
V	SCR (A)	Serial Clock Receive	input
X	SCR (B)	Serial Clock Receive	input
P	SD (A)	Send Data	output
S	SD (B)	Send Data	output
U	SCTE (A)	Serial Clock Transmit External	output
W	SCTE (B)	Serial Clock Transmit External	output
Y	SCT (A)	Serial Clock Transmit	input

*Comments refer to interface panel connector and are applicable for DTE operation onl

Table 7-4 (Cont.)

V.35/306 Connector Pin Assignments

PIN	CIRCUIT	V.35/306 DESCRIPTION	COMMENT*
AA or a	SCT (B)	Serial Clock Transmit	input
BB	SCT (A) (DCE mode only)	Spare	output (disabled in DTE mode)
Z	SCT (B) (DCE mode only)	Spare	output (disabled in DTE mode)
EE	GND	Spare	internally connected to B
CC	DTE/DCE	Spare	connected to B in DCE mode

*Comments refer to interface panel connector and are applicable for DTE operation only.

Table 7-5

Cross Reference For Connector Pin Lettering

MIL. SPEC. C-22857-C Connector	Commercial Connector
A	A
B	B
C	C
D	D
E	E
F	F
H	H
J	J
K	K
L	L
M	M
N	N
P	P
R	R
S	S
T	T
U	U
V	V
W	W
X	X
Y	Y
Z	Z
AA	a
BB	b
CC	c
DD	d
EE	f
FF	g
HH	h
JJ	i
KK	j
LL	k
MM	m
NN	n

Balanced Drivers:	Signal swing (Bipolar): ± .55 volts ± .1 into 100 ohms. Short circuit current: less than 100 mA. Rise Time: less than 20 nsec. Generator Impedance: 100 ohms.
Balanced Receivers:	Load resistance: 100 ohms.
Unbalanced Drivers: (RS-232C)	Rise time: greater than 20 microsecond. Generator Impedance: less than 100 ohms. Short circuit current: less than 100 mA. Output level (7K Load): ± 10 volts typical.
Unbalanced Receivers:	Load Impedance: 3K to 7K ohms. Maximum input voltage: ± 25 volts.

7.6 WECO 303 INTERFACE MODULE (MODEL 40182)

7.6.1 Introduction

The 303 Interface Module meets the interface specifications of the 303-type Wideband Data Stations, Bell System Technical Reference PUB 41302 (1974). This interface module, incorporated with a FIREBERD, is designed to act as data terminal equipment (DTE) for use in testing data communications equipment (DCE). The data is exchanged in a serial-binary format with a synchronous clock.

A cable is provided with each 303 Interface Module. This cable provides the connection between the 25 pin type-D connector on the interface module and the 303 Data-Station Connector (See Table 7-6).

The following sections provide a functional, switch, and specification description for the module.

7.6.2 Functional Description

The 303 Interface Module converts between the signal levels conforming to the WECO 303 Interface Specification and the TTL signal levels used in the FIREBERD.

This interface provides high-speed current-mode drivers for the Send Data (SD), Serial Clock Transmit External (SCTE), and the Request to Send (RS) outputs. The SD and SCTE signals are transmitted according to the 303 specification. The RS output is controlled by a FIREBERD front-panel RTS/RLSD switch.

There are six high-speed current-mode receivers, three of which directly drive the FIREBERD front-panel DSR, CTS, and RLSD (DTE) indicators. The other receivers consist of the Serial Clock Transmit (SCT), Receive Data (RD), and the Serial Clock Receive (SCR). The SCT signal is sent to the transmit section of the FIREBERD where it may be selected for use by the GENERATOR CLOCK TX (RCV) switch. The SCR and RD signals are sent to the receive section for error analysis. An EIA RS-232 type driver is provided to hold the DTR line in the ON condition.

Table 7-6

Connector Pin-Out Description

D-TYPE PINOUTS	BURNDY CABLE PINOUTS	CIRCUIT	DESCRIPTION	COMMENT
1	E	SD	Send Data	output
2	H	SCTE	Serial Clock Transmit External	output
3	D	RS	Request to Send	output
4				open
5	M	AGC	AGC Center Conductor	input (RLSD LED)
6	J	SCT	Serial Clock Transmit	input
7	C	CS	Clear to Send	input
8				open
9	F	DSR	Data Set Ready	input
10	K	RD	Receive Data	input
11	L	SCR	Serial Clock Receive	input
12				open
13				open
14	ES	(SD)	ground	
15	HS	(SCTE)	ground	
16	DS	(RS)	ground	
17				open
18	MS	DTR (outer conductor)	Data Terminal Ready	output - tied ON (EIA RS-232)
19	JS	(SCT)	ground	
20	CS	(CS)	ground	
21				open
22				open
23	KS	(RD)	ground	
24	LS	(SCR)	ground	
25				open

The interface module also includes a loop-test relay. When the TEST switch is in the LOOP position on the FIREBERD front panel, this relay connects the SD and SCTE driver outputs to the RD and SCR receiver inputs. It also disconnects the driver and receiver signals from the interface connector.

7.6.3 Switch and Indicator Description

RCV CLK POLARITY

The RCV CLK POLARITY switch controls the polarity of the received clock (SCR) inside the FIREBERD. In the NORMAL position, the FIREBERD is prepared to accept data which is falling edge (ON-OFF) valid as specified in the Bell 303 specification. In the INVERT position, the FIREBERD is prepared to receive data rising edge (OFF-ON) valid due to the inverted received clock.

TX CLK POLARITY

The TX CLK POLARITY switch controls the polarity of the clock used to develop the transmit clock (SCTE) and data functions inside the FIREBERD. The NORMAL position provides data-clock phasing as stated in the Bell 303 specification. The INVERT position provides data-clock phasing inverted to that in the Bell 303 specification.

NON STD TIMING

This indicator will illuminate when either or both clock switches are in the INVERT position.

7.6.4 Data-Clock Test Points

This section describes the relationship between the WECO 303 Interface Module data and clock signals and the FIREBERD rear-panel test points. The WECO 303 Interface Module is designed to accept a data Mark, signaling OFF as a signal with less than 5 mA. A data Space, signaling ON, is a signal greater than 23 mA.

RCV DATA/TX DATA

The signal at this test point is greater than 2.5 volts when the Received Data (RD) input at the interface module is a signal such that less than 5 mA of current is input to the 100-ohm receiver load (Mark). This test point provides a less than 0.4 volt signal when the Received Data (RD) input at the interface module inputs a signal greater than 23 mA (Space).

RCV TIMING/-

When the RCV CLK POLARITY switch is in the NORMAL position, the test point is greater than 2.5 volts when the current at the Serial Clock Receive (SCR) input is greater than 23 mA, and is less than 0.4 volts when the current at the SCR input is less than 5 mA. When the RCV CLK POLARITY switch is in the INVERT position, the test point is 2.5 volts when the current at SCR is less than 5 mA and is 0.4 volts when the current is greater than 23 mA.

TX DATA/RCV DATA

This test point provides a signal of greater than 2.5 volts when the data at the Send Data (SD) output of the interface module is less than 5 mA (Mark) when driving a 100-ohm load. A signal of less than 0.4 volts is provided at this test point when the SD output is greater than 23 mA (Space) when driving a 100-ohm load.

SEND TIMING/TERM TIMING

This test point provides a 2.5 volt signal when the clock signal at the Serial Clock Transmit (SCT) input is greater than 23 mA. The signal at this point is less than 0.4 volts when the SCT input receives a signal less than 5 mA. Use of the TX CLK POLARITY switch will not affect this relationship.

TERM TIMING/RCV TIMING

This test point provides a signal of at least 2.5 volts when the Serial Clock Transmit External (SCTE) output at the interface module is less than 5 mA. The signal at this test point is less than 0.4 volts when the SCTE output is providing a signal greater than 23 mA into a 100 ohm load. Use of the TX CLK POLARITY switch will not affect this relationship.

7.6.5 Specifications

General: Data Polarity: Data Mark/binary 1, Control Lead OFF, less than 5 mA. Data Space/binary 0, Control Lead ON, greater than 23 mA.

Drivers: Mark/OFF - less than 4 mA.
Space/ON - approximately 35 mA.

Receivers: Input Impedance: 100 ohms.
Open Circuit Voltage: -1 volt.
Maximum input voltage: 25 volts.
Thresholds: OFF or Mark less than 9.5 mA. ON or Space greater than 10.5 mA.

7.7 RS-232-C/V.24/MIL 188C CHARACTER INTERFACE MODULE (MODEL 40392)

7.7.1 Introduction

The Model 40392 Character Interface Module is compatible with the FIREBERD series of Data Error Analyzers. A FIREBERD equipped with this interface module can test a wide variety of character-oriented equipment and systems. The interface module normally operates as data terminal equipment (DTE) but will also operate as data communications equipment (DCE) by simply using the DTE to DCE conversion cable that is included.

The Model 40392 Character Interface Module is designed to convert between the TTL signals used within the FIREBERD and signals complying with EIA standard RS-232-C, CCITT Recommendations V.24 and V.28, and MIL standard 188C. Data generated within the FIREBERD is placed in a character format (see Figure 7-12) and transmitted at the user-selected baud rate. Received characters are stripped of start, stop, parity bits, and the extracted data are returned to the FIREBERD for error analysis. No transmit clock signals are provided and no receive clock signals are expected.

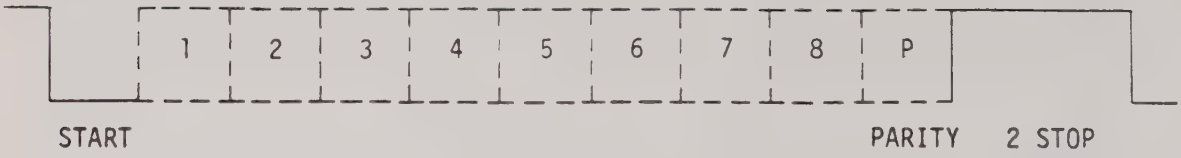
7.7.2 Functional Description

7.7.2.1 Switches

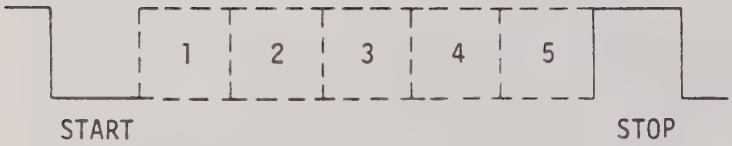
Several switches are provided on the interface module allowing the user to tailor the character format and baud rate to meet equipment requirements. These switches are described below.

BAUD RATE SEL

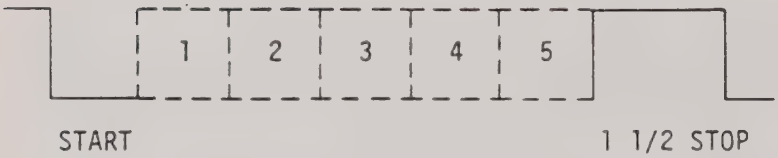
The outer ring of the rotary switch and the toggle switch closest to the rotary-switch control the baud rate. The toggle switch selects between an upper and lower rangeof frequencies. The outer ring of the rotary switch selects one of eight frequencies in that range. The receive and transmit baud rates are identical. The available baud rates are listed in Table 7-7.



(a) longest possible character



(b) shortest possible character



(c) 1 1/2 stop bit (5 data bits only)

Figure 7-12
Asynchronous Character Formats

Table 7-7
Baud Rates

LOWER RANGE OPTION	UPPER RANGE
75	1800
110	2000
134.5	2400
150	3600
300	4800
600	7200
1200	9600
	19.2K

NUMBER OF BITS

The inner ring of the rotary switch selects the number of data bits. Five through eight bits may be selected. See Table 7-8 for some common codes.

PARITY

A choice of even, odd, or no parity is available. The interface module does not check for parity errors, but a difference in the presence or absence of a parity bit may cause accumulated errors or a loss of synchronization.

STOP BITS

One or two stop bits may be used with 6, 7, or 8 data bit characters. For 5 data bits a choice of 1 or 1 1/2 stop bits is available.

Table 7-8
Common Codes

# Of Data Bits	Name
5	CCITT Alphabet #2
	Baudot
	Western Union Telex
	Western Union Telegraph
	United Press International
	American 60 WPM TWK
6	New York Stock Exchange
	BCDIC
7	ASCII
	CCITT Alphabet #5
8	EBCDIC

BIT ORDER

This switch controls the way the data bits are imbedded into the character format. The DATA SENTRY 10 and some other character-oriented test equipment require a normal setting. The Model 40234 Asynchronous Interface Module requires a reverse setting.

188C/NORM

The NORM position of this switch sets a mark to be a negative voltage. This is compatible with RS-232-C and specifications outlined in Recommendation CCITT V.28. The 188C position sets a mark to be a positive voltage. This complies with MIL STD 188C.

OPTIONAL BAUD RATE

A non-standard frequency may be requested. Consult factory.

7.7.2.3 Signaling

The following RS-232-C/V.24 signaling leads are implemented when the interface module is used as a DTE (data terminal equipment):

1. REQUEST TO SEND (CA/105) - controlled by a FIREBERD front-panel switch.
2. CLEAR TO SEND/READY FOR SENDING (CB/106) - displayed by the FIREBERD.
3. DATA SET READY (CC/107) - displayed by the FIREBERD.
4. DATA TERMINAL READY (CD/108-2) - held in the ON condition.
5. RECEIVED LINE SIGNAL DETECTOR (CF/109) - displayed by the FIREBERD.

The following signaling leads are implemented when the interface module is used as DCE (data communications equipment) using the DCE adaptor cable (see Figure 7-13):

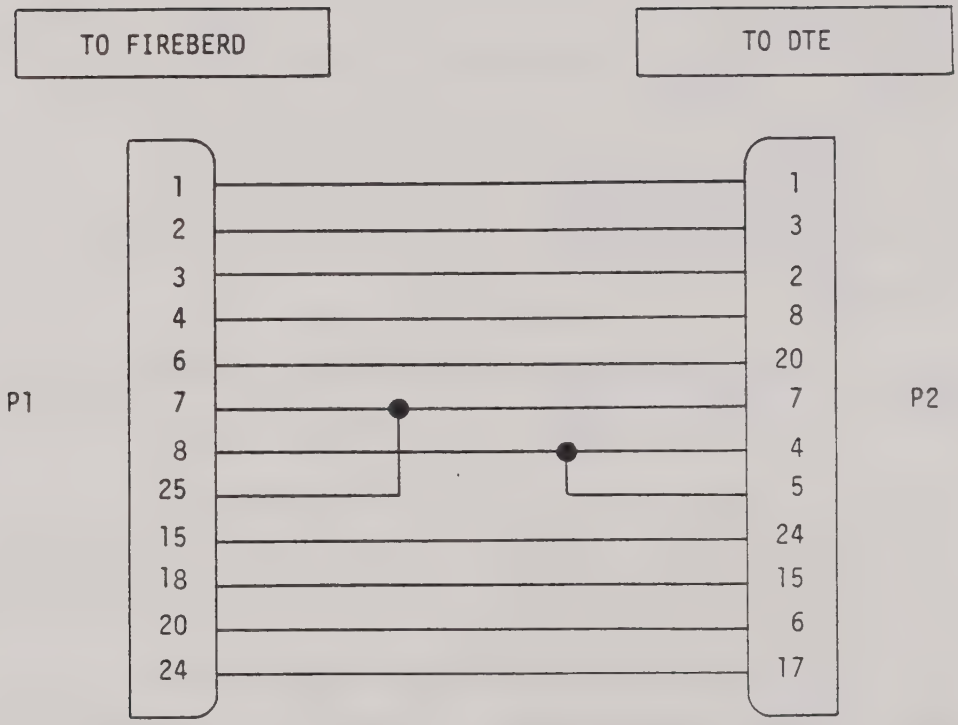
1. REQUEST TO SEND (CA/105) - displayed by the FIREBERD. Note that circuit CA is connected directly to circuit CB below at the DTE end of the cable.
2. CLEAR TO SEND/READY FOR SENDING (CB/106) - tied directly to circuit CA above at the DTE end of the special cable.
3. DATA SET READY (CC/107) - held in the ON condition.
4. DATA TERMINAL READY (CD/108-2) - displayed by the FIREBERD.
5. RECEIVED LINE SIGNAL DETECT (CF/109) - controlled by a FIREBERD front-panel switch.

7.7.3 Operation and Applications

7.7.3.1 Operation and Interface Test

Insert the Character Interface Module into the adaptor slot in the back of the FIREBERD Data Error Analyzer. Make sure the interface module is properly seated, then hand-tighten the two thumb screws.

CAUTION: FIREBERD power should always be OFF when inserting or removing interface modules.



P1:	25-Pin D-Subminiature, Male
P2:	25-Pin D-Subminiature, Female
Cable Length:	(9 inches)

Figure 7-13
DTE/DCE Adaptor Cable (Model 10257)

The FIREBERD must have the generator clock set to external interface clock (EXT I/F) to work properly. Select an appropriate data pattern for testing using the PATTERN switch (for example, try the 511 pattern). Set the other FIREBERD controls as follows:

ERROR INSERT	OFF
TEST	LOOP
DISPLAY	ERRORS
MODE (Slide Switch)	SINGLE ERROR MODE
AUTO SYNC	ENABLE
RESULT HOLD/UPDATE/RESET	UPDATE
RTS/RLSD	ON

On the Character Interface Module, set the baud rate, parity, and stop bits. For most applications set the bit order switch to NORM. If you are communicating to a FIREBERD with a Model 40234 Asynchronous Interface Module, the data direction must be set to reverse. For testing MIL-188C systems simply set the switch to 188C. For RS-232-C or V.28 applications this switch should be set to NORM. Typical character interface settings are:

BAUD RATE	2400 BAUD
NUMBER OF DATA BITS	7 Bits
PARITY	EVEN
BIT ORDER	NORM
188C/NORM	NORM

After the power is turned ON, the FIREBERD should achieve synchronization, light the SYNC indicator, and show zero errors. Pressing the ERROR INSERT switch to SINGLE will add one to the error count display. If the FIREBERD achieves synchronization and errors can be inserted in the looped data stream, the FIREBERD's TEST switch can be set to NORM for system testing.

Determine if the FIREBERD must operate as a DTE or DCE. For DTE operation simply connect the FIREBERD directly to the circuit under test using a standard male-to-male 25-pin cable. For DCE operation, the DTE/DCE conversion cable must be connected to the interface module's D connector first; connection to the circuit under test can then be made using a standard male-to-male cable.

If the Character Interface Module switches are set properly and the system under test is functioning, the SYNC light should come on and no errors should be counted. (For very slow baud rates this could take several seconds.)

When two FIREBERDs are used in an end-to-end test, the Character Interface Modules in the FIREBERDs must be set identically.

7.7.3.2 FIREBERD Test Points

Transmit data is taken from the FIREBERD in bursts, with the desired number of data bits (5, 6, 7, or 8) being extracted approximately once per transmitted character. The clock signals used for obtaining data from the FIREBERD are substantially faster than the transmitted baud rate and are not necessarily coincident with the transmitted bit transitions. Figure 7-14 shows the TX DATA, TX CLK, and transmitted character relationships.

Received data is extracted from each character and is sent to the FIREBERD using a clock signal that is slightly slower than the selected baud rate. Figure 7-15 shows the RCV DATA, RCV CLK, and received character relationships.

7.7.3.3 Applications Information

The Character Interface Module can be controlled to test many code types and character formats. A few of the more common code types are listed in Table 7-8.

The Character Interface Module is designed so that the transmitted character stream is continuous, i.e., the final stop bit of one character is immediately followed by the start bit of the next character.

The data receiver is capable of handling baud rate differences (between transmit and receive baud rates) of approximately $\pm$ 3%. Note that excessive time between received characters may be interpreted by the FIREBERD 1500A as a data or clock loss (resulting in a sync loss), primarily at the lower baud rates.

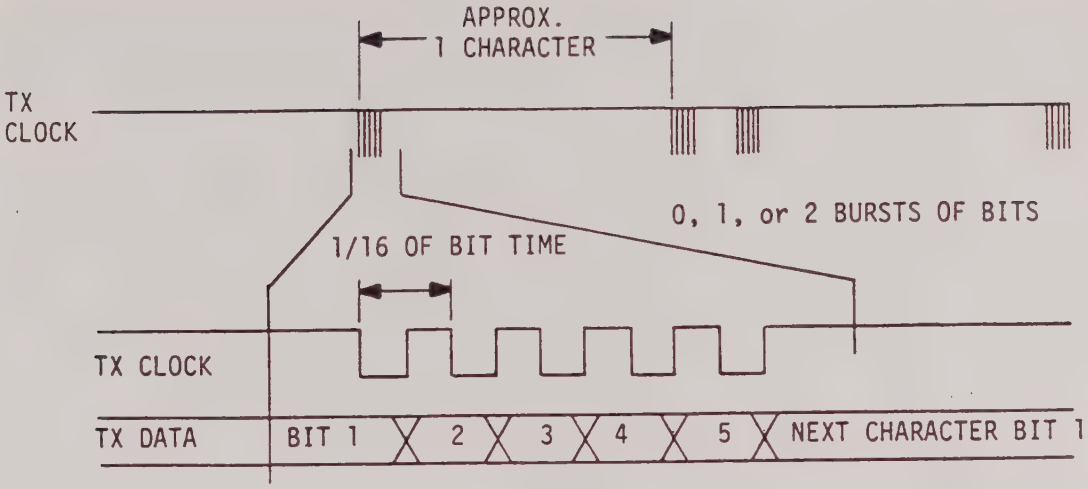


Figure 7-14

Tx Clk, Tx Data Test Points (5 data bits)

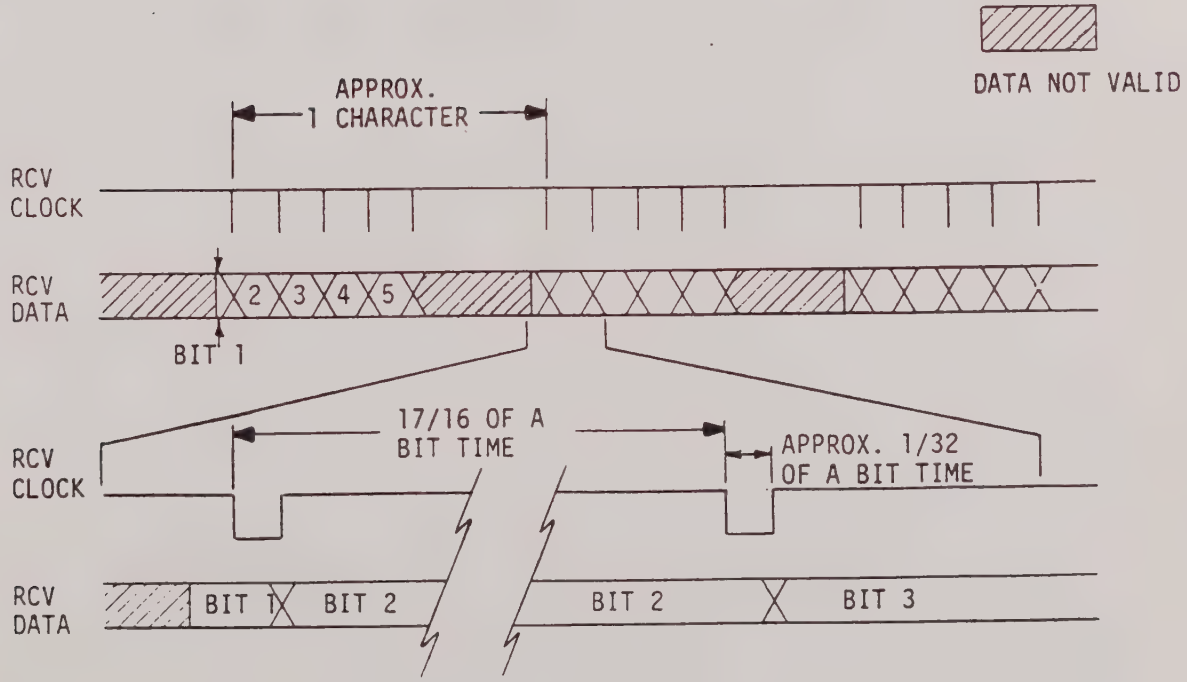


Figure 7-15

RCV Clk, RCV Data Test Points (5 data bits)

Many asynchronous receivers search only for a single stop bit; setting the number of STOP BITS switch to the 2 stop bits position effectively inserts a marking pause between characters.

Users of the Character Interface Module should note that, at baud rates below 600 baud, the "Seconds", "Error Seconds", and "Print Timer" functions on the FIREBERD 1500A will run slower than normal. These timing functions are designed to be synchronous with the receive clock and using the Character Interface Module at baud rates below 600 baud prevents sufficient transitions per unit time to assure correct timing operations.

7.7.4 Specifications

Selectable Baud Rates:

Lower Scale	option, 75, 110, 134.5, 150, 300, 600, 1200 baud
Upper Scale	1800, 2000, 2400, 3600, 4800, 7200, 9600, 19200 baud

Number of Data Bits Per Character	5, 6, 7, 8 bits
Number of Start Bits Per Character	1 bit
Number of Stop Bits Per Character	1, 2 bits (1, 1 1/2 for 5 data bits)
Parity Bit Control	Even, odd, none

Data Line Drivers:

	Min	Max
Norm Space/188C Mark	+5.0	+6.0 volts
Norm Mark/188C Space	-6.0	-5.0 volts
Transition Time (10%-90%)	3.0 microseconds typical	

Control Line Drivers:

		Min	Max
RTS/RLSD (also DTR/DSR)	ON	+5.0	+6.0 volts
RTS/RLSD	OFF	-6.0	-5.0 volts

Both Data and Control Line Drivers:	Min	Max
Impedance	-	50-ohms Max
Short Circuit Current	-	150 mA Max

Line Receivers:

	Min	Max
Load Impedance	3000	7000 ohms
Input Voltage -25 +25 volts		
Positive transition threshold	-	2.25 volts
Negative transition threshold	.75	-- volts

7.8 RS-232 DTE INTERFACE MODULE (MODEL 40112)

7.8.1 Introduction

The FIREBERD RS-232 Interface Module meets the specifications of the Electronic Industries Association's RS-232C Standard dated August 1969. This interface module, incorporated with the FIREBERD, is designed to act as data terminal equipment (DTE) for use in the testing of data communications equipment (DCE). The data is exchanged in a serial-binary format with a synchronous clock.

A female RS-232 D-type connector is provided on the interface module panel. An interconnecting male-to-male cable may be purchased separately. The following sections will provide a functional, switch, test point, and specification description of the RS-232 Interface Module.

7.8.2 Functional Description

The RS-232 DTE Interface Module is designed to convert between the serial-binary signals specified by the EIA RS-232C standard and the TTL signals used in the FIREBERD.

Drivers are provided for the Transmit Clock, Transmit Data, Request to Send (RTS), and Data Terminal Ready (DTR). The RTS output is controlled by a FIREBERD front-panel switch. The DTR output is tied high on this interface module.

There are six receivers, three of which directly drive FIREBERD front-panel signaling indicators. The Transmit Signal Element Timing (DCE Source) is sent to the transmit section of the FIREBERD where it may be selected for use by the GENERATOR CLOCK TX (RCV) switch. The other two receiver signals (RCV Timing and RCV Data) are sent to the receive section of the FIREBERD for error analysis.

The interface module also includes a loop test relay. When the TEST switch is in the LOOP position on the FIREBERD front panel, this relay will connect the TX Data and Clock driver outputs to the RCV Data and Clock receiver inputs. It will also disconnect the driver and receiver signals from the interface connector.

7.8.3 Data-Clock Test Points

This section describes the phase relationship between the RS-232C DTE Interface Module data and clock input signals and the FIREBERD rear-panel test points.

RCV DATA/TX DATA

The signal at this test point is greater than 2.5 volts when the received data at the BB input is less than -3 volts (Mark). The signal at the test point is less than 0.4 volts when the signal at the BB input is greater than +3 volts (Space).

RCV TIMING/-

This test point provides a TTL signal, equivalent to the Receiver Signal Element Timing (DD) signal at the input to the RS-232 Interface Module. With the RCV CLK (DD) switch in the NORMAL position, the signal at this test point is greater than 2.5 volts when the signal at the DD input is greater than +3 volts. The test-point signal is less than 0.4 volts when the signal at the DD input is less than -3 volts. When the RCV CLK (DD) switch is in the INVERT position, the signal at this test point is inverted with respect to the signal at the DD input.

TX DATA/RCV DATA

This test point provides the TTL equivalent of the signal at the Transmitted Data (BA) output of the RS-232 Interface Module. The signal at this test point is greater than 2.5 volts when the signal at the BA output is less than -3 volts (Mark). The test-point signal is less than 0.4 volts when the signal at the BA output is greater than +3 volts (Space).

SEND TIMING/TERM TIMING

The signal at this test point is the TTL equivalent of the signal at the Transmit Signal Element Timing (DB) input at the interface module. This test point provides a signal of greater than 2.5 volts when the signal at the DB input is greater than +3 volts. The signal is less than 0.4 volts at the test point when the DB input is less than -3 volts.

TERM TIMING/RCV TIMING

This test point provides a TTL signal equivalent to that signal at the Transmit Signal Element Timing output (DA) at the RS-232 Interface Module. This test point is greater than 2.5 volts when the signal at DA is greater than +3 volts. The test-point signal is less than 0.4 volts when the signal at DA is less than -3 volts.

7.8.4 Switch and Indicator Description

RCV CLK (DD)

The RCV CLK (DD) switch controls the polarity of the received clock inside the FIREBERD. In the normal (NORM) position, the FIREBERD is prepared to accept data which is falling edge (ON-OFF) valid as specified in the EIA RS-232C Standard. In the INVERT position, the FIREBERD is prepared to receive data that is rising edge (OFF-ON) valid due to the inverted received clock.

TX CLK (DA or DB)

The TX CLK switch controls the polarity of the clock used to develop the transmit clock and data signals inside the FIREBERD. The NORM position transmits data-clock phasing as stated in the RS-232C specification. In the INVERT position, the transmit data and clock phasing will be inverted with respect to the RS-232C specification.

NON-STANDARD TIMING

This indicator will illuminate when either or both clock switches are in the INVERT position.

For connector pin assignments see Table 7-9.

7.8.5 Specifications

General: Maximum Speed: 20 kb/s (per RS-232C).
Data Polarity: Data Mark/binary "1"; control lead OFF: less than -3 volts.

Table 7-9

RS-232C DTE Interface Connector Pin Assignments

PIN	CIRCUIT	RS-232C DESCRIPTION	Lead Status on FIREBERD Interface Adaptor
1	AA	Protective Ground	internally connected to Pin 7
2	BA	Transmitted Data	output
3	BB	Received Data	input
4	CA	Request to Send	output
5	CB	Clear to Send	input
6	CC	Data Set Ready	input
7	AB	Signal Ground (Common Return)	internally connected to Pin 1
8	CE	Received Line Signal Detector	input
9	--	(Reserved for Data Set Testing)	open
10	--	(Reserved for Data Set Testing)	open
11		Unassigned (see Sec. 2.3)	open
12	SCF	Sec. Received Line Signal Detector	open
13	SCB	Sec. Clear to Send	open
14	SBA	Secondary Transmitted Data	open
15	DB	Transmit Signal Element Timing (DCE Source)	input
16	SBB	Secondary Received Data	open

Table 7-9 (Continued)

RS-232C DTE Interface Connector Pin Assignments

PIN	CIRCUIT	RS-232C DESCRIPTION	Lead Status on FIREBERD Interface Adaptor
17	DD	Receiver Signal Element Timing (DCE Source)	input
18		Unassigned	open
19	SCA	Sec. Request to Send	open
20	CD	Data Terminal Ready	output - tied ON
21	CG	Signal Quality Detector	open
22	CE	Ring Indicator	open
23	CH/CI	Data Signal Rate Selector (DCE/DTE Source)	open
24	DA	Transmit Signal Element Timing (DTE Source)	output
25		Unassigned	open

Data Space/binary "0"; control lead ON: greater than 3 volts.
Output Rise Time: greater than 20 microseconds.
Generator Impedance: less than 100 ohms.

Drivers: Signal Swing: 10v ± 2 volts into 7K ohms typical.
Short Circuit Current: less than 100 mA.

Receivers: Load Impedance: 3K to 7K ohms.
Maximum Input Voltage: ± 25 volts.

7.9 RS-232 DTE/DCE INTERFACE MODULE (MODEL 40236)

7.9.1 Introduction

The RS-232 DTE/DCE Interface Module was designed to meet the Electronics Industries Association (EIA) RS-232C Interface Standard. This interface, incorporated with the FIREBERD, enables the FIREBERD to act as data terminal equipment (DTE) for use in testing data communications equipment (DCE). A special adaptor cable, included with the interface, allows the FIREBERD to act as DCE for testing DTE. The data is exchanged in a serial-binary format with a synchronous clock.

7.9.2 Operation as Data Terminal Equipment

7.9.2.1 Functional Description - DTE Operation

The RS-232 DTE/DCE Interface Module converts the signal characteristics specified by the RS-232 specification to the TTL signals used by the FIREBERD. The adaptor cable should not be attached and the DCE (DA)/DCE (DB)/DTE switch on the interface module should be in the DTE position.

In a typical RS-232 circuit, the DCE supplies timing to the DTE (FIREBERD) on the Transmit Signal Element Timing (DB) lead. With the FIREBERD's GENERATOR CLOCK TX (RCV) switch in the EXT I/F position, the FIREBERD will generate Transmit Data (BA) and Transmit Signal Element Timing (DA) coincident with the clock received on the Transmit Signal Element Timing (DB).

If the FIREBERD's GENERATOR CLOCK TX (RCV) switch is set for any of the internal rates (including FA, FB, FC, or FD if so equipped) the FIREBERD will ignore the transmit Signal Element Timing (DB) and generate Transmit Data (BA) and Transmit Timing (DA) coincident with the selected internal rate. Data and Clock signals are received on the Receive Data (BB) and Receiver Signal Element Timing (DD) leads for error analysis.

A toggle switch on the FIREBERD front panel allows Request to Send (RTS) to be turned on and off. Clear to Send (CTS), Data Set Ready (DSR), and Receive Line Signal Detector (RLSD) are received and their status displayed on the FIREBERD front panel.

When the TEST switch on the front panel of the FIREBERD is placed in the LOOP position, relays on this module will connect the transmit clock and data outputs to the receive clock and data inputs. User connections need not be removed during loop test. External timing for loop test can be provided on the TX Signal Element Timing (DB) lead (DCE source) or through the rear-panel BNC connector. The loop-test function tests actual drivers and receivers that are used in normal operation.

7.9.2.2 Switch and Indicator Description - DTE Operation

Two clock switches are provided on the interface module panel. Setting the TX CLK switch to the INVERT (down) position causes Transmit Data to be valid on the rising edge of the selected clock source instead of the falling edge (normal). Setting the RCV CLK switch to the INVERT (down) position causes the FIREBERD to expect valid Receive Data (BB) on the rising edge of Receive Signal Element Timing (DD) instead of the falling edge (normal). A NON-STD TIMING indicator will illuminate when either or both clock switches are in the INVERT position.

7.9.2.3 Data/Clock Test Points - DTE Operation

This section describes the relationship between the signals at the interface connector and the FIREBERD rear-panel test points.

RCV DATA/TX DATA

The signal at this point is greater than 2.5 volts when the Receive Data at the (BB) input is less than -3 volts (Mark). The signal at the test point is less than 0.4 volts when the signal at the (BB) input is greater than +3 volts (Space).

RCV TIMING

This test point provides a TTL signal equivalent to the Receive Signal Element Timing (DD) Signal at the input to the interface module. With the RCV CLK (DD) switch

in the NORMAL position, the signal at this test point is greater than 2.5 volts when the signal at the (DD) input is greater than +3 volts. The test-point signal is less than 0.4 volts when the signal at the (DD) input is less than -3 volts. When the RCV CLK (DD) switch is in the INVERT position, the signal at this test point is inverted with respect to the signal at the (DD) input.

TX DATA/RCV DATA

This test point provides the TTL equivalent of the signal at the Transmit Data (BA) output. The signal at this test point is greater than 2.5 volts when the signal at the (BA) output is less than -3 volts (Mark). The test-point signal is less than 0.4 volts when the signal at the (BA) output is greater than +3 volts (Space).

SEND TIMING/TERM TIMING

The signal at this test point is the TTL equivalent of the signal at the Transmit Signal Element Timing (DB) input at the interface connector. This test point provides a signal of greater than 2.5 volts when the signal at the (DB) input is greater than +3 volts. The signal is less than 0.4 volts at the test point when the (DB) input is less than -3 volts.

TERM TIMING/RCV TIMING

This test point provides the TTL signal equivalent to the signal at the Transmit Signal Element Timing (DA) output at the interface connector. This test point is greater than 2.5 volts when the signal at (DA) is greater than +3 volts. The test-point signal is less than 0.4 volts when the signal at (DA) is less than -3 volts.

7.9.3 Operation As Data Communications Equipment

7.9.3.1 Functional Description - DCE Operation

The RS-232 DTE/DCE Interface Module can easily be configured to look like data communications equipment (DCE) for testing of data terminal equipment (DTE) by using a special adaptor cable (included).

NOTE: The adaptor cable must be connected in order to select either DCE (DA) or DCE (DB) on the interface panel. The interface defaults to the DTE operation in the absence of the adaptor cable. All signals are referred to by the name of the signal at the cable output - not the end connected to the FIREBERD.

In a typical RS-232 circuit, the DCE (FIREBERD) supplies timing to the DTE on the Transmit Signal Element Timing (DB). The DTE will return Transmit Data (BA) and Transmit Signal Element Timing (DA) to the FIREBERD for error analysis.

Two DCE timing modes are selectable on the interface panel: DCE (DA) and DCE (DB). In the DCE (DA) position, TX data and the DTE source timing signal (DA) are sent to the receive section of the FIREBERD for error analysis. In the DCE (DB) position, TX data and the internally generated DB are sent to the receive section of the FIREBERD for error analysis.

With the FIREBERD's GENERATOR CLOCK TX (RCV) switch set to the EXT I/F position, RCV Data and Receive Signal Element Timing will be generated coincident with Transmit Signal Element Timing (DA) from the DTE. (Note that with the DTE signal DA must not be generated from the DCE TX Timing Signal (DB)). FIREBERD may also generate RCV Data and RCV Timing coincident with any of the internal rates (including FA, FB, FC, and FD if so equipped).

When the TEST switch on the front panel of the FIREBERD is placed in the LOOP position, a relay on the interface module will connect transmit clock and data to receive clock and data. User connections need not be removed during loop test. External timing for loop test can be provided on the Transmit Signal Element Timing (DA) lead or through the rear-panel BNC connector. The loop-test function tests actual drivers and receivers that are used in normal operation. Note that the TX Timing (DB) driver is not tested nor is the adaptor cable.

A toggle switch on the FIREBERD front panel allows Receive Line Signal Detector (RLSD) to be turned ON and OFF in DCE mode. Data Terminal Ready (DTR) and Request

to Send (RS) are received and their status displayed on the FIREBERD front panel. Th DTE generated Request to Send (RS) is tied directly back to the DTE received Clear t Send (CS) in addition to being displayed on the FIREBERD front panel.

7.9.3.2. Switch and Indicator Description - DCE Operation

Two clock switches are provided on the interface module panel. The TX CLK switc in the INVERT (down) position causes FIREBERD to expect valid transmit data on th rising edge of the selected clock source instead of the falling edge (Normal). Setting th RCV CLOCK switch to the INVERT (down) causes the FIREBERD to generate vali Receive Data on the rising edge of the selected clock source instead of the falling edg (Normal). A NON-STD TIMING indicator will illuminate when either or both cloc switches are in the INVERT position.

7.9.3.3 Data/Clock Test Points - DCE Operation

This section describes the phase relationship between the interface connector dat and clock signals and the FIREBERD rear-panel test points.

RCV DATA/TX DATA

This signal at this test point is greater than 2.5 volts when the Transmit Data at th (BA) input to the adaptor cable is less than -3 volts (Mark). The signal at the test point i less than 0.4 volts when the signal at (BA) is greater than +3 volts (Space).

TX DATA/RCV DATA

This test point provides the TTL equivalent of the signal at the BB output. The signa at this test point is greater than 2.5 volts when the signal at the BB output is less than - volts (Mark). The test-point signal is less than 0.4 volts at the test point when the BB output is greater than +3 volts (Space).

SEND TIMING/TERM TIMING

The signal at this test point is the TTL equivalent to that signal at the Transmit Signal Element Timing (DB) input. This test point provides a signal 2.5 volts when the signal at the DB input is greater than +3 volts. The signal is less than 0.4 volts at the test point when the DB input is less than -3 volts.

TERM TIMING/RCV TIMING

This test point provides a TTL signal equivalent to that at the Receive Timing Signal (DD) output. This test point is greater than 2.5 volts when the signal at DD is greater than +3 volts and less than 0.4 volts when DD is less than +3 volts.

7.9.4 Specifications

For connector pin assignments see Table 7-10.

General:	Maximum Speed: 20 kb/s (per RS-232C).
	Data Polarity: Data Mark/binary "1"; control lead OFF: less than -3 volts. Data Space/ binary "0"; control Lead ON: greater than +3 volts.
Drivers:	Output rise time: greater than 20 microseconds.
	Generator Impedance: less than 100 ohms.
	Signal Swing: 10V $\pm$ 2V into 7K ohms typical.
	Short Circuit Current: less than 100 mA.
Receivers:	Load Impedance: 3K to 7K ohms.
	Maximum Input Voltage: $\pm$ 25 volts.

Table 7-10

RS-232C DTE/DCE Connector Pin Assignments

PIN	CIRCUIT	RS-232C DESCRIPTION	LEAD STATUS	
			Interface Panel Connector (DTE Operation)	DTE End of Adaptor Cable (DCE Operation)
1	AA	Protective Ground	internally connected to Pin 7	
2	BA	Transmitted Data	output	input
3	BB	Received Data	input	output
4	CA	Request to Send	output	input
5	CB	Clear to Send	input	connected to Pin 4
6	CC	Data Set Ready	input	output
7	AB	Signal Ground (Common Return)	internally connected to Pin 1	
8	CF	Received Line Signal Detector	input	output
9	--	(Reserved for Data Set Testing)	open	open
10	--	(Reserved for Data Set Testing)	open	open
11		Unassigned	open	open
12	SCF	Secondary Received Line Signal Detector	open	open
13	SCB	Secondary Clear to Send	open	open
14	SBA	Secondary Transmitted Data	open	open
15	DB	Transmit Signal Element Timing (DCE Source)	input	output
16	SBB	Secondary Received Data	open	open
17	DD	Receiver Signal Element Timing	input	output

Table 7-10 (Continued)

RS-232C DTE/DCE Connector Pin Assignments

PIN	CIRCUIT	RS-232C DESCRIPTION	LEAD STATUS	
			Interface Panel Connector (DTE Operation)	DTE End of Adaptor Cable (DCE Operation)
18	DD	Unassigned	FIREBERD use only	open
19	SCA	Secondary Request to Send	open	open
20	CD	Data Terminal Ready	output tied ON	input
21	CG	Signal Quality Detector	open	open
22	CE	Ring Indicator	open	open
23	CH/CI	Data Signal Rate Selector (DCE/DTE Source)	open	open
24	DA	Transmit Signal Element Timing (DTE Source)	output	input
25	--	Unassigned	FIREBERD use only	open

7.10 RS-232 ASYNCHRONOUS (ISOCHRONOUS) (CLOCK RECOVERY)/ SYNCHRONOUS INTERFACE ADAPTOR MODULE (MODEL 40232)

7.10.1 Introduction

The Model 40232 RS-232 Asynchronous (Isochronous)/Synchronous Interface Module allows a FIREBERD to test both synchronous and asynchronous (isochronous) (bit timing recovery) communications channels. This interface module enables a FIREBERD to act as data terminal equipment (DTE) for use in testing data communications equipment (DCE).

Data is exchanged in serial-binary format either with a synchronous clock signal (synchronous operation) or without a clock signal (asynchronous (isochronous) operation). Data, signaling, and other connections are made via a standard 25-pin female D connector.

The following sections will provide specifications and functional descriptions of the RS-232 Asynchronous (Isochronous) Interface Module.

7.10.2 Functional Description

The RS-232 Asynchronous (Isochronous)/Synchronous Interface Module is used to convert between the TTL signals used within the FIREBERD and signals conforming to EIA Standard RS-232-C.

The interface module has three modes of operation:

1. Synchronous (DCE Source) - Data is transmitted and received with a synchronous clock and timing is provided by the DCE under test.

2. Synchronous (Internal or Baud Rate Source) - Data is transmitted and received with a synchronous clock and timing is generated either by the FIREBERD internal clock sources or by the interface baud rate generator.

3. Asynchronous (Isochronous) - The ASYNC switch position selects asynchronous (isochronous) operation which is commonly used to test asynchronous modems. In this position, data is transmitted and received without a clock signal. Transmit timing is generated by the interface module and receive timing is recovered internally from the data transitions.

The interface module contains a loop-test multiplexer which connects the TTL-level transmit data and clock signal directly to the FIREBERD receive data and clock inputs when the FIREBERD's TEST switch is placed in the LOOP position. This loop test is useful in verifying correct operation of the FIREBERD and the interface module. When in the Loop Test mode, the transmit data and clock (if used) signals are unaffected. The receive data and clock (if used) terminations are not affected by the Loop Test mode, although these signals do not reach the FIREBERD itself.

7.10.3 Synchronous (DCE Source) Operation

When operating in the Synchronous (DCE Source) mode, the GENERATOR CLOCK TX (RCV) switch on the FIREBERD must be in the EXT I/F position. The desired clock signal can then be provided through Pin 15 of the D connector. For connector pin assignments see Table 7-11.

Transmit data and clock will be available at connector Pins 2 and 24. Receive data and clock are expected at connector Pins 3 and 17.

7.10.4 Synchronous (Internal or Baud Rate Source) Operation

When operating in the Synchronous (Internal or Baud Rate Source) mode, transmit timing is generated by one of three sources:

1. The FIREBERD GENERATOR CLOCK TX (RCV) switch, selecting any internal frequency including FA, FB, FC or FD if so equipped.

Table 7-11

RS-232 Isochronous/Synchronous Interface Adaptor

Pin Assignments

PIN #	SIGNAL NAME	DIRECTION	COMMENT
1	AA-GND	--	
2	BA-TX DATA	To DCE	
3	BB-RCV DATA	From DCE	
4	CA-REQUEST TO SEND	To DCE	Front Panel Controlled
5	DB-CLEAR TO SEND	From DCE	
6	CC-DATA SET READY	From DCE	
7	AB-GND	--	
8	CF-RCV LINE SIGNAL DETECTOR	From DCE	
9	Not used	--	
10	Not used	--	
11	Not used	--	
12	Not used	--	
13	Not used	--	
14	Not used	--	
15	DB-TRANSMIT TIMING (DCE SOURCE)	From DCE	Not used in Isochronous mode
16	Not used	--	
17	DD-RECEIVE TIMING (DCE SOURCE)	From DCE	Not used in Isochronous mode
18	Not used	--	
19	Not used	--	
20	CD-DATA TERM READY	To DCE	Tied ON
21	Not used	--	
22	Not used	--	
23	Not used	--	
24	DA-TRANSMIT TIMING	To DCE	Disabled in Isochronc mode
25	Not used	--	

2. The rear-panel BNC connector with the FIREBERD GENERATOR CLOCK TX (RCV) switch set to EXT BNC.

3. The interface module BAUD RATE switch with the FIREBERD GENERATOR CLOCK TX (RCV) switch set to EXT I/F. Any of 11 baud rates* can be selected.

Transmit data and clock will be available at connector Pins 2 and 24. Receive data and clock are expected at connector Pins 3 and 17.

Note that any signals appearing at connector Pin 15 are ignored by the interface module.

7.10.5 Isochronous Operation

When operating in the Asynchronous (Isochronous) mode (ASYNC switch position), the FIREBERD GENERATOR CLOCK TX (RCV) switch must be set to the EXT I/F position. Any of 11 transmit baud rates may be selected via the BAUD RATE switch on the interface module. Receive timing is generated by the interface module through the use of an all-digital bit synchronizer (clock recovery circuit).

Transmit data will be available from connector Pin 2 and receive data is expected at connector Pin 3. No transmit timing is provided in the Asynchronous (Isochronous) mode and Pin 24 is held at a constant Mark. Signals appearing at connector Pins 15 and 17 are ignored by the interface module.

Because the clock recovery circuit requires receive data transitions for synchronization, the Asynchronous (Isochronous) Interface Module will operate with any of the FIREBERD standard test patterns except the Mark and Space patterns.

---

* At 75 baud, the "Seconds", "Error Seconds", and "Print Timer" functions will operate slower than normal and should not be used.

7.10.6 Signaling

The following signals are implemented by the Asynchronous (Isochronous) Interface Module and the FIREBERD:

1. Request to Send (CA-Pin 4) - Controlled by a FIREBERD front-panel switch.

2. Clear to Send (CB-Pin 5) - displayed by the FIREBERD.

3. Data Set Ready (CC-Pin 6) - displayed by the FIREBERD.

4. Data Terminal Ready (CD-Pin 20) - held in the ON condition.

5. Receive Line Signal Detect (CF-Pin 8) - displayed by the FIREBERD.

7.10.7 Specifications

General: Maximum Synchronous Speed ..... 20 kb/s nominal
Asynchronous (Isochronous) Baud Rates .... 75, 150, 300, 600, 1200, 1800, 2400, 3600, 4800, 7200, 9600 baud

Line Drivers:

Slew Rate	30 volts per microsecond maximum.
Impedance	100 ohms maximum.
Short Circuit Current	50 mA maximum.
Data Mark (binary 1)	-3.0 volts maximum.
Data Space (binary 0)	+3.0 volts minimum.
Signal Swing (type, 7K ohm load)	10 $\pm$ 2 volts.

Line Receivers:

Load Impedance	3000 ohms minimum. 7000 ohms maximum.
Maximum Input Voltage	$\pm$ 25 volts.
Data Mark (binary 1)	0.0 volts maximum.
Data Space (binary 0)	2.0 volts minimum.

7.11 LAB INTERFACE MODULE (MODEL 40204)

7.11.1 Introduction

The Lab Interface Module is a versatile interface unit which allows the FIREBERD to test a wide variety of data handling devices. Capable of driving any load from 50 ohms to high impedances, with user-selectable receiving impedances, the Lab Interface Module allows the user to select bipolar or unipolar, balanced or unbalanced operating modes.

Data is exchanged in a serial-binary format with a synchronous-clock signal. All connections with the interface module are made through BNC connectors.

The following sections will provide descriptions and the specifications for the Lab Interface Module.

7.11.2 Functional Description

The Lab Interface Module is designed to convert between the TTL signals used within the FIREBERD and the user-selected signal type.

Data generated in the FIREBERD is transmitted through the TX DATA jack. The synchronous-transmitted clock signal is sent through the TX CLK OUT jack. Data is returned to the FIREBERD for error analysis through the RCV DATA jack. The synchronous returned clock is sent through the RCV CLK jack.

Timing for the transmitted data signal may be developed either by selecting one of the FIREBERD's internal clock signals or by setting the FIREBERD GENERATOR CLOCK TX (RCV) switch to the EXT I/F or EXT BNC position and providing a clock signal via the EXT TX CLK IN jack on the interface module or the FIREBERD rear-panel BNC connector.

The Lab Interface Module also includes a loop-test multiplexer designed to connect the TTL-Level transmit data and clock signals directly to the FIREBERD TTL-Level receive data and clock inputs when the TEST switch is in the LOOP position. When in the

Loop Test mode, the Lab Interface transmit data and clock signals are unaffected. The receive data and clock signal terminations are not affected by the Loop Test mode, although these signals do not reach the FIREBERD itself.

7.11.3 Switch Operation and Control

The Lab Interface Module has three switches which each have four positions affecting the operation of the unit. By properly selecting the switch positions, any of up to 64 operating modes may be accommodated.

INPUT IMPEDANCE SWITCH

The INPUT IMPEDANCE switch affects the three inputs: RCV DATA, RCV CLK, and EXT TX CLK IN. When in the 50 ohms position, the switch places a 50-ohm terminating resistor across each of the three inputs. When placed in the 75 ohms position, a 75-ohm resistor terminates each of the three inputs. The 100 ohms position provides a 100-ohm terminating resistor and the 8K ohms position allows the input signals to go directly to the line receiver integrated circuits with no other resistive termination.

MODE SWITCH

The MODE switch controls the mode of operation of all five data and clock jacks. Two major modes of operation are available: The Bipolar configuration (both positive and negative with respect to ground) and the Unipolar configuration (positive only with respect to ground). For each of these two modes, an Unbalanced arrangement (the outer conductor tied directly to ground) or a Balanced arrangement (the outer connector used as a complementing driver) are selectable.

Figure 7-16 shows the output voltage levels and the signal arrangements for each of the four selectable modes. Figure 7-17 shows the voltage levels required by the RCV DATA, RCV CLK, and EXT TX CK IN signal jacks for proper operation. Note that the voltage levels required are independent of the terminating impedances.

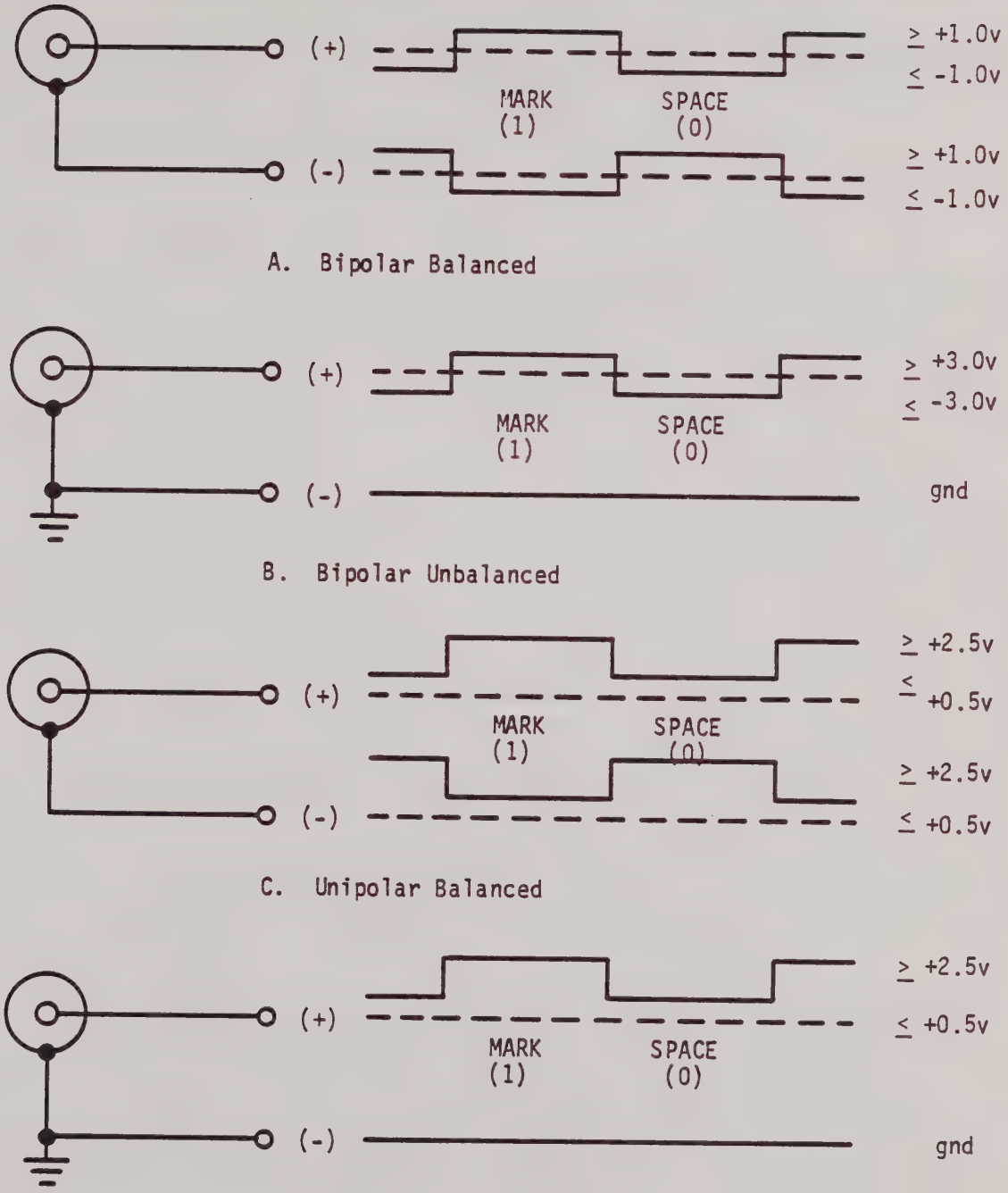
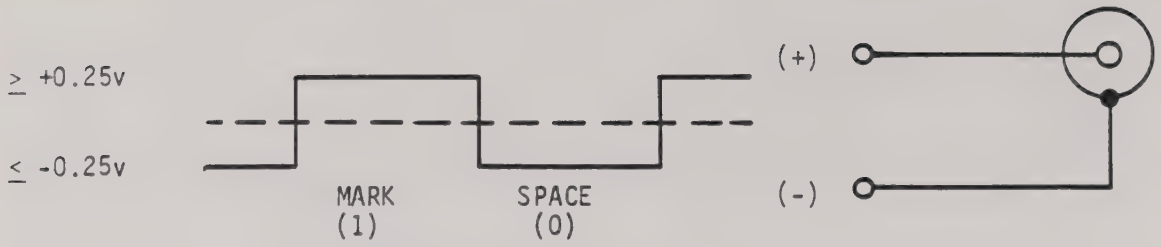
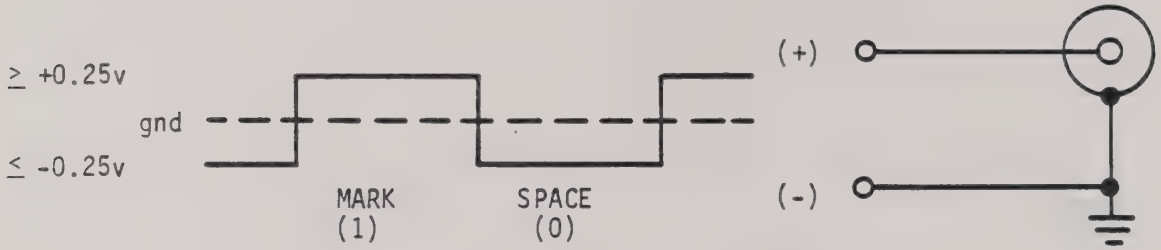


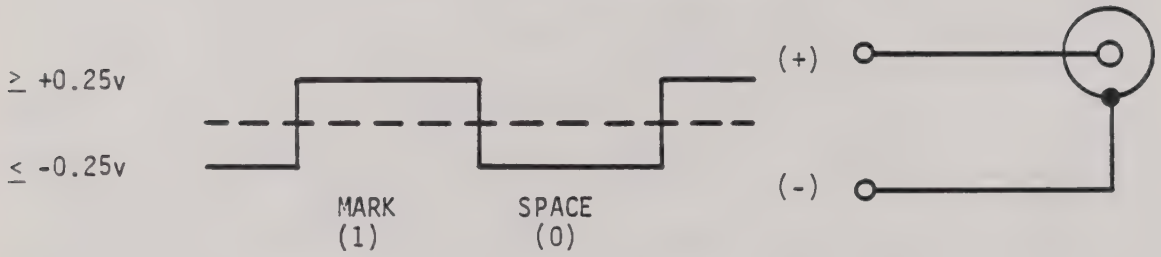
Figure 7-16
Selectable Operating Modes
Transmit Data and Clock Outputs



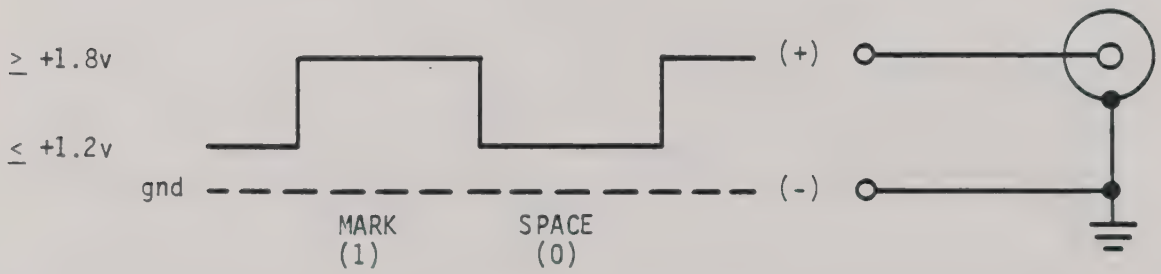
A. Bipolar Balanced (Differential voltage)



B. Bipolar Unbalanced



C. Unipolar Balanced (differential voltage)



D. Unipolar Unbalanced

Figure 7-17
Selectable Operating Modes
Minimum Required Input Levels

CLOCK PHASING SWITCH

The CLOCK PHASING switch controls the data and clock phase relationships for both the transmit and receive ports. For both the transmit and receive sides, either falling-edge valid or rising-edge valid can be selected. Figure 7-18 shows the four available switch positions and the resultant data/clock relationships.

7.11.4 Receive Test Points

This section describes the relationship between the Lab Interface Module input and output signals and the FIREBERD rear-panel test points.

RCV DATA/TX DATA

The signal level at this test point will be greater than 2.5 volts when the receive data at the interface module is a Mark (logic 1), and will be less than 0.4 volts when the receive data is a Space (logic 0).

RCV TIMING/-

When the CLOCK PHASING switch is set to the "↑↑" or "↓↑" (rising-edge valid receive data) position, the voltage at this test point will be less than 0.4 volts when the center conductor of the RCV CLK input is more positive than the outer conductor. The voltage at the test point will be greater than 2.5 volts when the center conductor is more negative than the outer conductor. If the CLOCK PHASING switch is set to the "↓↓" or "↑↓" positions, then the above relationships are reversed.

TX DATA/RCV DATA

The signal at this test point will be greater than 2.5 volts when the transmit data is a Mark (logic 1) and will be less than 0.4 volts when the transmit data is a Space (logic 0).

TERM TIMING/RCV TIMING

The signal at this test point will be less than 0.4 volts when the center conductor of the TX CLK output is more positive than the outer conductor. The voltage at this test

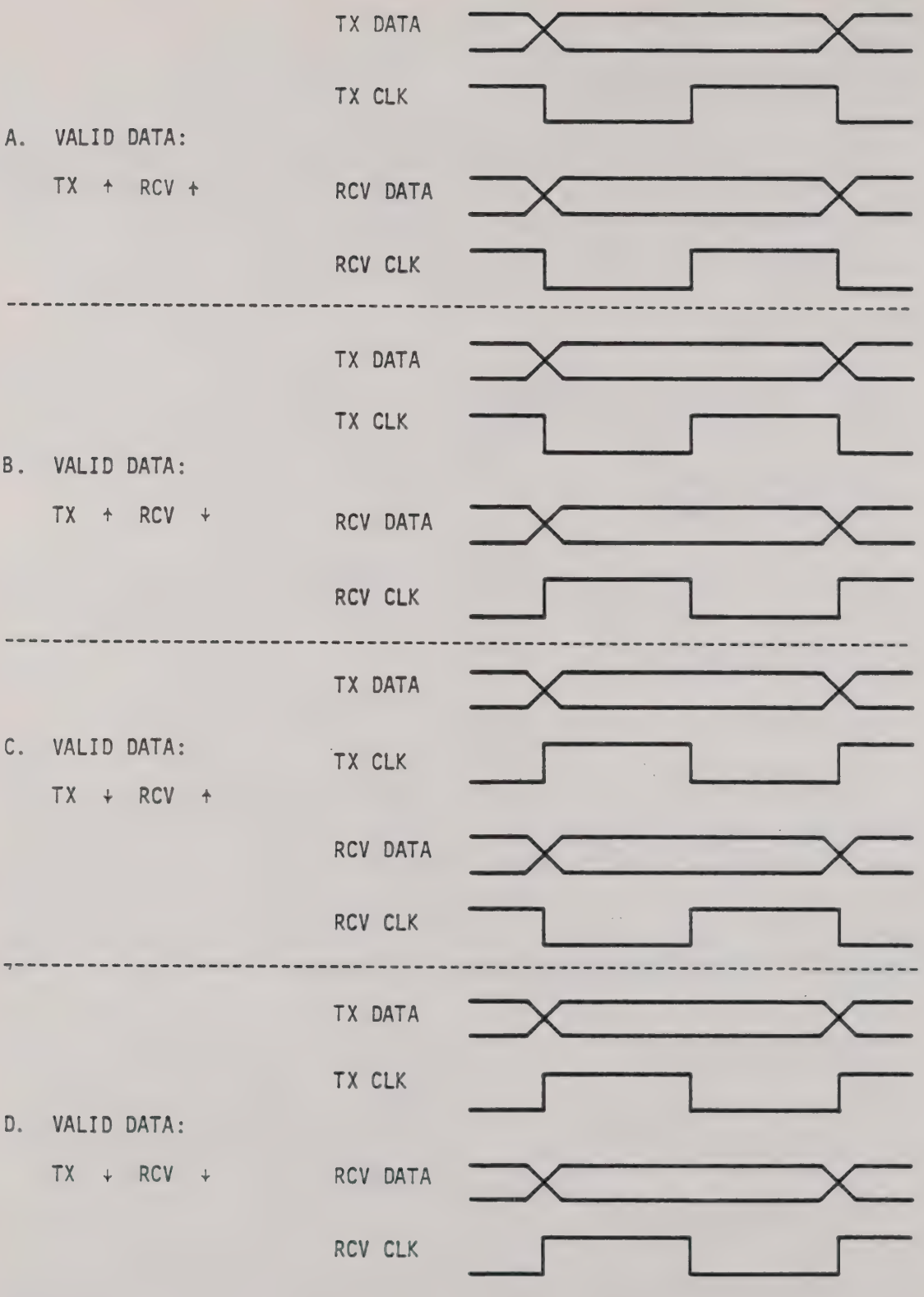


Figure 7-18
Clock Phasing Selections

point will be greater than 2.5 volts when the center conductor is more negative than the outer conductor. Use of the CLOCK PHASING switch will not affect this relationship.

7.11.5 Applications Information

The following information is provided to aid in using the Lab Interface Module to its best advantage.

When operating at a high bit rate or when driving long cables, it is recommended that a terminating impedance be placed at the receiving end. The Lab Interface Module line drivers are low-impedance drivers and can operate into any load down to 50 ohms. The terminating impedance will serve to reduce ringing and cable crosstalk.

When supplying the Lab Interface Module with an external clock input, note that the external clock signal must be in the same mode (e.g. Unipolar Unbalanced) as the transmit and receive data and clock signals.

The transmit data and clock outputs are high level (greater than 19 dBm into 50 ohms) and caution should be used when connecting to sensitive equipment.

When operating in the Unipolar Unbalanced mode with the INPUT IMPEDANCE switch set to 8K ohms, the transmit and receive data and clock signals can bedirectly connected to any TTL-family circuits. The Lab Interface Module inputs and outputs are compatible with all TTL families (e.g. Schottky TTL, LS TTL).

When operating in the Unipolar Balanced mode with the INPUT IMPED OHMS switch set to either 8K ohms or 100 ohms and with the CLOCK PHASING switch set to "↓↓", the interface module should be functionally compatible with RS-422A systems.*

When operating in the Bipolar Unbalanced mode with the INPUT IMPED OHMS switch set to 8K ohms and with the CLOCK PHASING switch set to "↓↓", the interface module should be functionally compatible with RS-232C, RS-423A, or Military Standard 188-114 bipolar unbalanced systems.

When operating in the Bipolar Balanced mode with the INPUT IMPED OHMS switch set for 100 ohms and the CLOCK PHASING switch set to "↓↓", the Lab Interface Module should be functionally compatible with Standard MIL-188-114 bipolar balanced, and with a pad on the outputs, V.35 systems.*

7.11.6 Specifications

Output Levels

Bipolar Balanced:	± 2.0 volts minimum differential voltage. (+19.0 dBm minimum into 50 ohms). (+17.3 dBm minimum into 75 ohms).
Bipolar Unbalanced:	± 3.0 volts DC minimum. (+22.6 dBm minimum into 50 ohms). (+20.8 dBm minimum into 75 ohms).
Unipolar Balanced:	± 2.0 volts minimum differential voltage. (+19.0 dBm minimum into 50 ohms). (+17.3 dBm minimum into 75 ohms).
Unipolar Unbalanced:	+2.5 volts DC minimum Mark (logic 1). +0.5 volts DC maximum Space (logic 0).

Input Levels

Bipolar Balanced:	± 0.25 volts minimum differential voltage. (+1.0 dBm @ 50 ohms; - 0.5 dBm @ 75 ohms). ±12.0 volts DC maximum with respect to FIREBERD ground.

* Full compliance with the mentioned system parameters is not guaranteed.

Bipolar Unbalanced:	+0.25 volts DC minimum Mark (logic 1). -0.25 volts DC minimum Space (logic 0). (+1.0 dBm @ 50 ohms; - 0.5 dBm @ 75 ohms).
Unipolar Balanced:	± 0.25 volts minimum differential voltage. (+1.0 dBm @ 50 ohms; - 0.5 dBm @ 75 ohms). ± 12.0 volts DC maximum with respect to FIREBERD ground.
Unipolar Unbalanced:	+1.8 volts DC minimum Mark (logic 1). +1.2 volts DC maximum Space (logic 0).

Maximum Input Levels

The following voltage levels are not to be exceeded at any time (differential voltage for Balanced operation, volts DC for Unbalanced operation):

50 ohms	± 3.3 volts (23.4 dBm)
75 ohms	± 4.0 volts (23.3 dBm)
100 ohms	± 4.7 volts (23.4 dBm)
8K ohms	± 15.0 volts

7.12 T1 INTERFACE MODULE (Model 40365)

7.12.1 Introduction

The T1 Interface Module allows the FIREBERD 1500, 1500A, 2000, and 2000-1 test sets to test communications systems that use the Bell System T1 (DS-1) 1.544 Mb/s Digital Channel Service and similar systems. The T1 signals are serial, differential return-to-zero (RZ) pulses with alternate mark inversion (AMI) coding.

In addition to making the conversions between the TTL levels of the FIREBERD and the T1 signals, the T1 Interface Module has the following capabilities:

- o It accepts low-level degraded signals, regenerates the data, and recovers the clock timing from the data.
- o The FIREBERD's 2^{20}-1 pseudorandom pattern can be modified to conform to the Bell System quasi-random signal source (QRSS) pattern having no more than 14 consecutive zeros.
- o Bipolar Violations (BPVs) in the received data can be detected and converted to bit errors for processing by the FIREBERD.
- o Bipolar Violations (BPVs) can be inserted in live traffic at various error rates for Automatic Protection Switching (APS) testing.

Figure 7-19 shows a block diagram of the T1 Interface Module.

7.12.2 Operating Modes

7.12.2.1 Bit Error Detection (NORM switch setting)

In this mode, bipolar violations are ignored and the received T1 data are sent to the FIREBERD for bit error analysis.

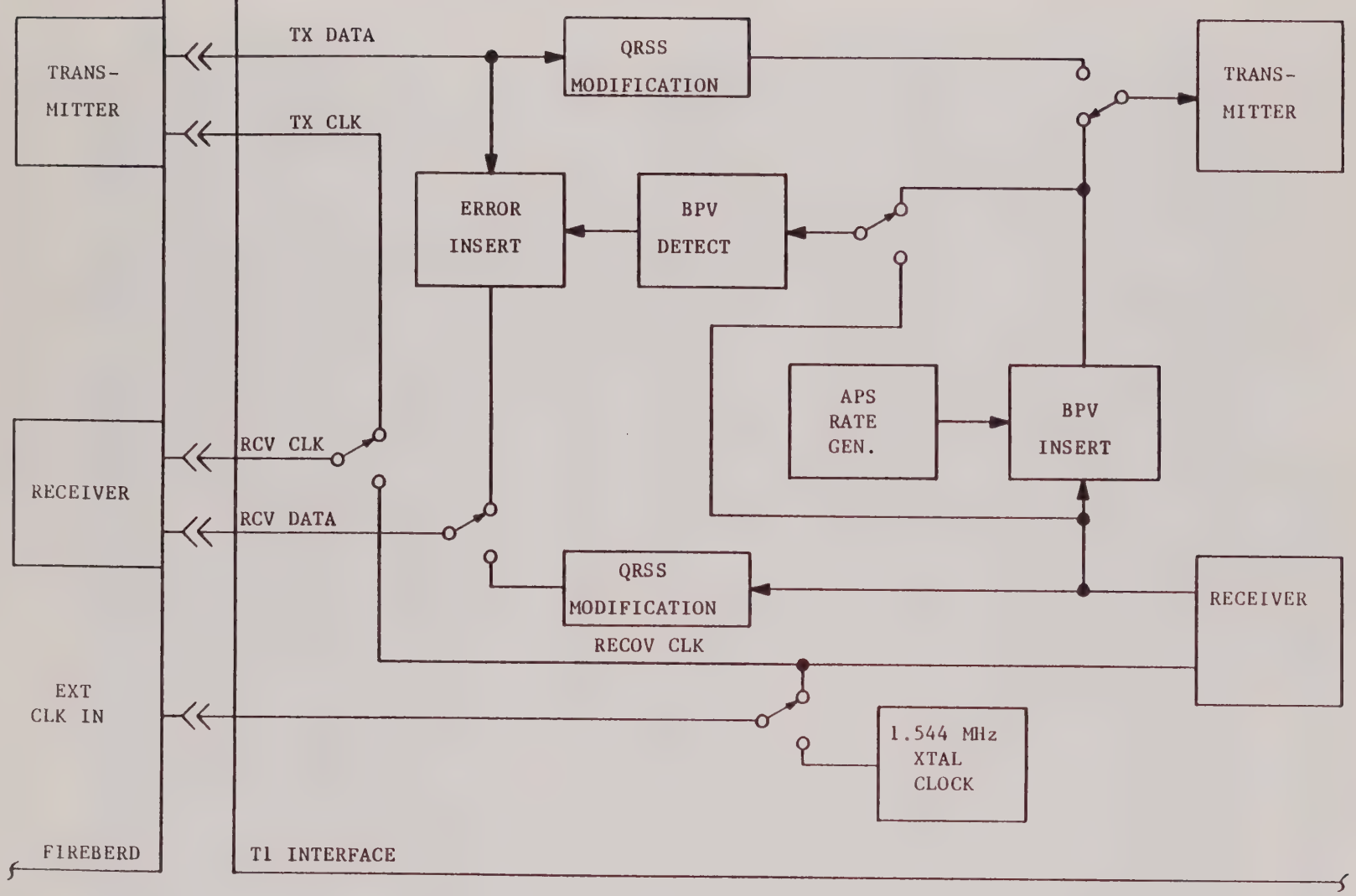


Figure 7-19

Block Diagram T1 Interface Adaptor

7.12.2.2 Bipolar Violation Detection (BPV setting)

The interface module includes circuitry for detecting two successive ones with the same polarity. When this mode of operation is being used, the output of the FIREBERD is looped back to its input by the interface module and a bit error is inserted in the looped-back pattern for each bipolar violation in the incoming signal. The output of the T1 Interface Module is the pattern selected on the FIREBERD front panel. A fail-safe circuit automatically breaks the loop back path when no T1-input signal is detected.

7.12.2.3 APS Testing (APS switch setting)

Bipolar violations may be inserted in live traffic for testing Automatic Protection Switching in T1 systems. The input of the interface module is retransmitted with BPVs inserted in the transmitted data. BPVs are spaced as evenly as possible for each of the switch-selected rates.

In the APS Testing mode, the output of the FIREBERD is looped back to its input by the interface module and a bit error is inserted in the looped-back pattern for each inserted BPV. This provides a means of verifying the error rates as they are generated.

A fail-safe circuit automatically breaks the loopback path when no T1-input signal is detected.

7.12.3 Loop Test

7.12.3.1 Bit Error Detection Mode (NORM switch setting)

The interface module includes a relay which is activated by the FIREBERD front-panel TEST switch. In the TEST position, the data-line driver is connected to the data-line receiver. This provides a quick verification of the operation of the FIREBERD and its interface in the Bit Error Detection mode. The input and output connectors need not be removed during the test because complete isolation is provided by the relay when testing. Note that a source of transmit timing must be provided for Loop Testing and the RECOV (LOOP) position of the interface module TX TIMING switch should not be used.

7.12.3.2 Bipolar Violation Detection Mode (BPV setting)

When the combination of TEST and BPV switch positions is selected, operation of the FIREBERD and T1 Interface Module should appear the same as when the TEST and NORM positions are selected. Note that the ability of the BPV detection-circuitry to detect BPVs is not checked in this mode, as no BPVs are generated. Malfunctions of the BPV-detection circuitry are likely to show up, however, due to false error detection. A more complete check of the BPV detection circuitry is provided by operating the interface in the APS mode setting and providing an external source of T1 signals. In the APS mode, the insertion of bipolar violations is checked using all the BPV-detection circuitry except the receiver. The RECOV (LOOP) position of the interface module TX TIMING switch should not be used in this mode.

7.12.3.3 APS Testing Mode (APS switch setting)

The interface module will not function when the combination of TEST and APS switch settings is selected. This is because the received data is retransmitted in APS mode, but the transmitted data is looped back to the receiver by the TEST switch.

7.12.4 FIREBERD Indicators

7.12.4.1 Received Data Indicator

When the T1 Interface Module is used with a Model 1500 or 1500A FIREBERD, an input signal consisting of a continuous string of ones will cause only the MARK indicator to illuminate. Absence of an input signal will cause only the SPACE indicator to illuminate. When the T1 Interface Module is used with a FIREBERD Model 2000 or 2000-1, any input signal containing data transitions will cause the DATA INV indicator to illuminate.

7.12.4.2 RCV CLK ACTIVITY Indicator

The RCV CLK indicator will be illuminate when a normal T1 signal is being received. Absence of an input signal will extinguish the indicator.

7.12.5 Transmit Clock

There are four clock sources available for use as the source of transmit timing:

- o An externally supplied signal input through the FIREBERD's rear-panel BNC connector.
- o An oscillator installed in the FIREBERD as FA, FB, etc.
- o A crystal oscillator located on the interface module.
- o The clock recovered from the incoming T1 data.

The latter two sources are selected by placing the FIREBERD GENERATOR CLOCK or CLOCK SELECT switch in the EXT or EXT I/F position and placing the TX TIMING switch in either the XTAL or RECOV (LOOP) position.

7.12.6 Switches

The following switches are provided on the panel of the interface module:

MODE

A 3-position toggle switch that selects Bit Error Detection (NORM), Bipolar Parity Violation Detection (BPV), or APS Test (APS) operating mode.

APS TEST

This pair of concentric rotary switches selects the error rates for APS testing. The center knob is the sequence control and the outer knob is the range control. No errors are inserted when the sequence switch is in the START position. The error rates that can be generated are listed in Table 7-12. The same rates are given as powers of 10 in Table 7-13.

Table 7-12

APS Error Rates

Sequence	STD/ 51A	Range				
		1 E-3	1 E-4	1 E-5	1 E-6	1 E-7
Start	STD	0	0	0	0	0
No Transfer	STD	5.0 E-4	5.0 E-5	5.0 E-6	3.2 E-7	5.0 E-8
Transfer	STD	2.0 E-3	2.0 E-4	2.0 E-5	1.3 E-6	2.0 E-7
No Restore	STD	5.0 E-4	5.0 E-5	5.0 E-6	3.2 E-7	5.0 E-8
Restore	STD	3.2 E-5	3.2 E-6	3.2 E-7	2.0 E-8	3.2 E-9
Start	51A	N/A	0	0	0	0
No Transfer	51A	N/A	5.0 E-5	5.0 E-6	5.0 E-7	5.0 E-8
Transfer	51a	N/A	2.0 E-4	2.0 E-5	2.0 E-6	2.0 E-7
No Restore	51A	N/A	1.3 E-4	1.3 E-5	1.3 E-6	1.3 E-7
Restore	51A	N/A	5.0 E-5	5.0 E-6	5.0 E-7	5.0 E-8

Table 7-13

APS Error Rates As Powers Of Ten

Sequence	STD/ 51A	Range				
		1 E-3	1 E-4	1 E-5	1 E-6	1 E-7
Start	STD	0	0	0	0	0
No Transfer	STD	10 E-3.3	10 E-4.3	10 E-5.3	10 E-6.5	10 E-7.3
Transfer	STD	10 E-2.7	10 E-3.7	10 E-4.7	10 E-5.9	10 E-6.7
No Restore	STD	10 E-3.3	10 E-4.3	10 E-5.3	10 E-6.5	10 E-7.3
Restore	STD	10 E-4.5	10 E-5.5	10 E-6.5	10 E-7.7	10 E-8.5
Start	51A	N/A	0	0	0	0
No Transfer	51A	N/A	10 E-4.3	10 E-5.3	10 E-6.3	10 E-7.3
Transfer	51A	N/A	10 E-3.7	10 E-4.7	10 E-5.7	10 E-6.7
No Restore	51A	N/A	10 E-3.9	10 E-4.9	10 E-5.9	10 E-6.9
Restore	51A	N/A	10 E-4.3	10 E-5.3	10 E-6.3	10 E-7.3

51A/STD

This toggle switch selects or 51A (for Culbertson and similar non-hysteresis switching equipment) STD (for Bell System hysteresis-type switching equipment) BPV insertion characteristics for APS testing.

TX Timing

This toggle switch selects the source of transmit timing when the FIREBERD GENERATOR CLOCK TX (RCV) or CLOCK SELECT switch is in the EXT or EXT I/F position. The XTAL position selects the crystal oscillator on the interface module; the RECOV (LOOP) position selects the clock recovered from the incoming T1 data. Note that the RECOV (LOOP) position should not be used with the FIREBERD in a Loop Test mode.

BRIDGE/TERM

This toggle switch selects input impedances of 100 or greater than 1000 ohms, for bridging or terminating a line. This switch should always be in the TERM position except when bridging a terminated line.

7.12.7 MOD/DIS Pluggable Jumper

The black plastic cover must be removed to gain access to this pluggable jumper located on the large circuit board. The interface module is shipped with the small square plastic jumper block in the position marked "MOD." In this position it modifies the transmitted signal to prevent more than 14 consecutive zeros. This modification affects primarily the 2^{20}-1 pattern. When used with the FIREBERD 1500A, if the 2^{15}-1 pattern is selected and the DATA switch is placed in the INVERT position, one zero-per-pattern repetition will be replaced by a one. A Space pattern is also converted to a Mark pattern.

When the FIREBERD is set for one of the modified patterns and is in sync with the received signal, a bit is inverted in the received signal at each of the positions where a zero was changed to a one in the transmitted pattern.

When the Pluggable Jumper is in the DIS position, the transmitted and received signals are not modified.

NOTE: Compatibility problems can arise when operating with another test set. These problems are all related to pattern modification to limit the number of consecutive zeros to 14.

As long as the pluggable jumper is in the MOD position, there will be no problem in operating with test sets used exclusively for T1 testing, such as the Bowmar Model 273A, which only transmits the Bell System QRSS pattern with the number of zeros limited to 14. If the T1 Interface Module has its pluggable jumper in the DIS position, disabling modification of the 2^{20}-1 pattern, each test set will see errors in the transmission of the other (2.95 E-5 BER).

To achieve compatibility with a FIREBERD equipped with a Model 40151 DS1 Interface Module using the 2^{20}-1 pattern, move the pluggable jumper to the DIS position. If it is not necessary to use the unmodified 2^{20}-1 pattern, no problems should be encountered as long as you do not use the 2^{20}-1 or Space patterns when the pluggable jumper is in the MOD position.

Two FIREBERDS equipped with T1 Interface Modules will also require the precautions described above if one of the T1 Interface Modules has its pluggable jumper set different from the other.

7.12.8 Connectors

Two WECO 310 jacks are provided for T1 line output and input. The jack sleeve is connected to ground; the differential signal appears across tip and ring. An optional cable is available for mating with a 15-pin D connector.

7.12.9 Specifications

Output

- o Output Pulse Amplitude: ± 3 ± 0.3 volts into 100 ohms with maximum unbalance of ± 0.15 volts.
- o Output Pulse Width: 324 ± 30 nsec (half amplitude) with maximum unbalance of ± 15 nsec.
- o Rise and Fall Times: 50 ± 25 nsec (10 to 90%).
- o Trailing Edge Overshoot: 10 to 30% of pulse height with decay to 10% or less of base line-to-peak value within 400 nsec.

Input

- o Input Threshold: The T1 Interface will function with a ± 3 volts input signal with up to 24 dB of cable attenuation.
- o Input Impedance: Terminating: 100 ohms ± 5%
  Bridging: 1000 ohms
- o Clock Recovery: The recovered clock shall remain in synchronization with the received data at a minimum "1"s density of 14 "0"s followed by 2 "1"s.

Crystal Oscillator

- o Frequency: 1.54400 MHz.
- o Accuracy and Stability: ± 35 ppm, 0°C to 50°C.
- o Drift: 5 ppm per year typical.

7.12.10 Operation

Table 7-14 summarizes the control settings for quick reference.

Table 7-14
Summary Of Control Settings

Function	MODE	51A/STD	APS TEST SEQUENCE	RANGE	TX TIMING	BRIDGE/TERM
Bit Error Detection	NORM	N/C*	N/C	N/C	XTAL or RECOV	BRIDGE** or TERM
Bipolar Violation Detection	BPV	N/C	N/C	N/C	RECOV	BRIDGE** or TERM
Automatic Protection Switching	APS	---- as appropriate ----			RECOV	TERM

* N/C = don't care
** BRIDGE should only be used when bridging a terminated line.

7.13 DS1/T1 (D4 FRAMING) INTERFACE ADAPTOR (Model 40405)

7.13.1 Introduction

The DS1/T1 (D4 Framing) Interface Module will allow the FIREBERD 1500A, 2000, and 2000-1 Data Error Analyzers to test communications systems that use the Bell System T1 (DS1) 1.544 Mb/s Digital Channel Service and similar systems. The T1 signals are serial, differential return-to-zero (RZ) pulses with alternate mark inversion (AMI) or bipolar with eight zero substitution (B8ZS) coding. The interface module will operate with either framed data, required by Digital Access Crossconnect Switches (DACS) and channel banks, or with unframed data as used in unswitched networks.

In addition to making the conversion between the TTL levels required by the FIREBERD and T1 signal levels, the interface module has the following capabilities:

- o It accepts low-level degraded signals, regenerates the data, and recovers the clock timing from the data.

- o The FIREBERD's 2^{20}-1 pseudorandom pattern can be modified to conform to the Bell System quasi-random signal source (QRSS) as specified by CB113.

- o Bipolar Violations (BPVs) in the received data can be detected and measurements of Violations Free Seconds or Bipolar Violation Rates can be made.

- o Data can be received and transmitted with or without the D1D, D2, D3, or D4 framing pattern inserted as the 193rd bit position.

- o Received data can be looped (retransmitted) without removing BPVs, thus, emulating a repeater or a Customer Service Unit (CSU) in loopback. Any BPVs in the received data are monitored.

- o A simplex-current path is provided which allows repeater powering when testing is performed on the "wet side" of a T1 span.

- Loop-up and loop-down codes can be transmitted to control loopbacks in compatible CSUs.

- The presence of B8ZS encoded data, frame patterns, or a Yellow Alarm condition cause signaling indicators to be illuminated.

The following sections will briefly describe the operating modes switch positions, indicators, and specifications. More detailed information is supplied in the Operating Manual For Model 40405 DS1/T1 (D4 Framing) Interface (ML 10552) which is supplied with each interface module.

7.13.2 Operating Modes

The following three sections briefly describe the three operating modes of the DS1/T1 (D4 Framing) Interface Module.

7.13.2.1 Bit Error Detection (MODE switch set to NORM)

In this mode, code violations are ignored and the received data are sent to the FIREBERD for bit error analysis. Data can be in either framed or unframed format. In framed data format the framing bits are not checked for errors. This is the normal mode of operation.

7.13.2.2 Bipolar Violation Monitoring (MODE switch set to BPV)

The interface module contains circuitry for detecting bipolar violations. A bipolar violation is defined as a Mark having the same polarity as the preceding Mark.

The position of the DATA switch does not affect the detection of BPVs. Any BPV which is part of the B8ZS code will not be counted as a violation regardless of the CODE switch position.

When the BPV mode of operation is being used, the output data from the FIREBERD is looped within the interface module and a bit error is inserted in the looped-back pattern for each BPV detected. The output of the interface module is the pattern selected on the FIREBERD front panel. This pattern will be unframed regardless of the position of the

DATA switch. The data is not required to match the pattern selected on the FIREBERD front panel, which allows "live traffic" to be monitored for BPVs. A fail-safe circuit will break the looped-back data path when no T1 data is present at the receive input.

7.13.2.3 Through Data Bipolar Violation Monitoring (MODE switch set to BPV-LOOP)

This mode allows all data received by the interface module to be retransmitted. The interface module emulates a repeater, or a CSU in loopback. Bipolar violations are monitored as described in the previous section, but not removed from the data when it is retransmitted.

The IMPED (impedance) and TIMING switches are functional in this mode. However, the TIMING switch has no effect on the data rate of the data being received and retransmitted by the interface module, but only affects the data being looped back on the interface. The TIMING switch should be set to the RECOV (LOOP) position to ensure accurate Bipolar Violation Rate measurements.

7.13.3 Loop Test

The interface module includes a relay which is activated by the TEST switch on the FIREBERD's front panel. In the LOOP position, the T1-line driver is connected to the T1-line receiver. This provides quick verification of the FIREBERD and its interface module in the Bit Error Detection mode. The input and output connectors need not be removed during the test because complete isolation is provided by the relay. It is recommended that the XTAL position of the TIMING switch be used with the FIREBERD's GENERATOR CLOCK TX (RCV) switch set to the EXT I/F position. The MODE switch should not be set to the BPV LOOP position when performing a loop test.

7.13.4 FIREBERD Indicators

Received Data Indicators

When the interface module is used with a FIREBERD 1500 or 1500A, an input signal consisting of a continuous string of ones (Marks) or framed ones in the Framed Data mode will cause the RCV MARK indicator to illuminate. Absence of an input signal for AMI

code or an all-Space pattern for B8ZS code will cause the RCV SPACE indicator to illuminated. Under normal operating conditions both the indicators labeled RCV SPACE and RCV MARK should illuminate.

RCV CLOCK Activity Indicator

The RCV CLOCK indicator will illuminate when an active T1-input signal is being received. Absence of an input signal will extinguish the indicator.

DSR Indicator (B8ZS Detect)

The DSR indicator on the front panel of the FIREBERD will illuminate when a B8ZS code is detected in the receive data. The detection is not dependent on any switch position and is functional in all modes of operation.

B8ZS detection may be disabled by removing a jumper wire (JW2) from the interface module. This may be necessary if the FIREBERD is set to print on signaling change and B8ZS codes are detected sporadically causing unwanted printouts. The time constant of the circuit is long enough that none of the FIREBERD's pseudorandom patterns will cause signaling change printouts.

RLSD Indicator (Frame Detect)

The RLSD indicator will illuminate when a framing pattern is present in the receive data. The frame pattern can be either D1D, D2, D3, or D4 framing. Frame detection is functional in all modes and switch position combinations.[1] The frame detection circuitryprevents false synchronization indications on unframed pseudorandom patterns. Frame detection may be disabled by removing a jumper wire (JW3) from the interface module.

CTS Indicator (Bit 2 or Yellow Alarm)

The CTS indicator will illuminate when the Yellow Alarm condition is detected in the received framed data. A Yellow Alarm is detected when 255 consecutive channel samples have bit two set to zero. This feature may be disabled by removing a jumper wire (JW1) from the interface module.

7.13.5 FIREBERD Switches

The RTS switch is used to initiate the transmission of either the loop-up or loop-down code. The OFF to ON transition of the RTS switch will cause the loop-up code of "10000" to be transmitted repetitively for 5.5 seconds. The ON to OFF transition of the RTS switch will cause the loop-down code of "100" to be transmitted repetitively for 5.5 seconds. Once a loop code is triggered, further transitions of the RTS switch are ignored for 5.5 seconds. The loop codes are unframed regardless of the position of the DATA switch.

A pluggable jumper (JW6) is provided on the interface module to disable this feature. See Section 7.13.9 for details. It should be noted that the switch triggers the loop-code circuitry during its transition from ON to OFF or OFF to ON. If the RTS switch is in the OFF position and it is desired that the loop-down code be transmitted the following sequence of events should occur:

- The FIREBERD's power should be turned off.
- The RTS switch should be toggled from OFF to ON.
- The power should be turned on.
- The RTS switch should be toggled from ON to OFF.

Failure to follow the above procedure would require that the loop-up code be sent prior to sending the loop-down code.

Prior to generating the loop code, determination should be made as to whether a loop already exists at the far end or at some intermediate point between the two CSUs. If this condition exists and a loop code is transmitted, it will be returned to the near-end CSU

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[1] Except a framed all-zero pattern with B8ZS coding.

and will cause its loop to be enabled. Should this occur, the FIREBERD will be isolated from the circuit and will be unable to break the loopback condition which must be cleared manually.

7.13.6 Transmit Clock

7.13.6.1 Unframed Transmit Timing

There are four sources of transmit timing when the DATA switch is in the UNFRAMED position.

- An externally supplied signal, input through the FIREBERD's rear-panel BNC connector.
- An oscillator installed in the FIREBERD as F_A, F_B, etc.
- The crystal oscillator located on the interface module.
- The clock recovered from the incoming T1 data stream.

The latter two sources are selected by placing the FIREBERD's GENERATOR CLOCK TX (RCV) switch in the EXT I/F position and placing the TIMING switch in either the XTAL or RECOV (LOOP) position.

7.13.6.2 Framed Transmit Timing

When using the interface module in the Framed Data mode there are only two clock sources that can be used as the transmit-timing source.

- The crystal oscillator located on the interface module.
- The clock recovered from the incoming T1-data stream.

The FIREBERD's GENERATOR CLOCK TX (RCV) switch must be in the EXT I/F position.

7.13.7 Switches

MODE

The MODE switch is a 3-position toggle switch that selects the operating mode of the DS1/T1 (D4 Framing) Interface Module. The NORM switch setting routes the data to the FIREBERD for logical bit error analysis. Both the BPV LOOP and the BPV positions detect bipolar violations in the received data. Their differences lie in the source of transmit data. When the BPV LOOP position is chosen the interface module retransmits data that was received by the receiver, whereas the BPV position causes transmission of the pattern selected by the PATTERN switch.

When the BPV LOOP position is selected only the IMPED and TIMING switches on the interface module are functional.

CODE

The CODE switch is a 2-position toggle switch which selects the coding format of the output data. When the AMI position is selected, a Mark is encoded with a pulse which has polarity opposite to the Mark preceding it. A Space is coded as the absence of a pulse. The B8ZS (bipolar eight zero substitute) position provides a similar code except that strings of eight sequential 0's are replaced by the pattern 000V10V1 where V is a bipolar violation (BPV). This allows data that contains long strings of 0's to be transmitted on a T1 span without violating the ones density criterion.

This switch does not affect the reception or detection of B8ZS coded data. The receiver will replace each B8ZS sequence detected in the incoming data stream with a string of eight 0's regardless of the position of the CODE switch.

TIMING

The TIMING switch is a 2-position switch that selects the transmit-timing clock source when the FIREBERD's GENERATOR CLOCK TX (RCV) switch is in the EXT I/F position. The XTAL position selects a 1.544 MHz crystal located on the interface module. The RECOV (LOOP) position selects a clock recovered from the received data as the transmit-timing clock source.

IMPEDANCE

The IMPEDANCE switch is a 2-position toggle switch which selects the input impedance at the receive input. The TERM position provides a 100-ohm input impedance. The TERM position should be used when the FIREBERD is terminating the line. The BRIDGE position provides greater than 1000-ohms input impedance and should be used if a termination is already present on the line.

7.13.7.5 QRSS

The QRSS toggle switch allows the FIREBERD's 2^{20}-1 pattern to be modified to become the quasi-random signal source (QRSS) specified by AT&T for T1-span testing in compatibility bulletin CB113. In the ENABLE position, the 2^{20}-1 pattern is modified to contain a maximum of 14 consecutive 0's. The DISABLE position allows the pattern to be transmitted unmodified.

The ENABLE position should not be used with inverted or reversed 2^{20}-1 data pattern in the FIREBERD 1500A. The ENABLE position will also cause the interface module to modify the SP (Space) pattern into a MK (Mark) pattern. The ENABLE position does not affect any of the other patterns.

NOTE: It is recommended that the QRSS switch be set to the DISABLE position when the MK (Mark) and SP (Space) patterns are used.

DATA

The DATA switch is a 2-position toggle switch which determines whether the data is going to be transmitted and received framed or unframed. The FRAMED position of the switch causes transmission of data with a framing bit inserted every 192 data bits as the 193rd bit. The framing pattern is compatible with D1D, D2, D3, and D4 Channel Banks. The signaling bits in the 6th and 12th frames are included as part of the pseudorandom pattern (i.e. these bits are not stolen for signaling).

The framed data rate is 1.536 Mb/s. This is added to the framing bit rate of 8 kb/s to arrive at the T1 data rate of 1.544 Mb/s. Note the limitations to the selection of clock sources given in Section 7.13.6.2.

The UNFRAMED position allows data to be transmitted and received at the full 1.544 Mb/s without framing bits. This mode is compatible with TTC's Model 40365 T1 Interface Module.

7.13.8 Connectors

Two WECO 310 jacks are provided for T1-line output and input. The jack sleeve is connected to ground; the differential signal appears tip and ring. An optional cable is available for mating with a 15-pin D connector.

7.13.9 Specifications

7.13.9.1 T1 Transmitter

Connector

Connector Type:	WECO 310 jack.
Configuration:	Tip-Ring-Sleeve; Sleeve connected to ground, differential signal on Tip and Ring.

Pulse Mask

All specifications are for output terminated in 100-ohm resistive load. Meets pulse masks given in CCITT Recommendation G.703 and in Bell Publications CB113, CB119, CB143, PUB 41451, PUB 62411, and PUB 62508.

Pulse Amplitude:	$\pm$ 3 $\pm$ 0.3 volts with a maximum imbalance of $\pm$ 0.15 volts.

Half Amplitude Pulse Width:	324 ± 24 nsec with a maximum imbalance of ± 15 nsec.
Rise and Fall Times:	100 nsec maximum (10% to 90%).
Trailing Edge Overshoot:	10% to 30% of pulse height with decay to 10% of pulse height within 400 nsec.
Line Codes:	Bipolar (pseudo-ternary); selectable AMI or B8ZS.

Loopback Code Generation

Loop-Up Code:	Repetitive 10000, sent for 5.5 ± 0.4 seconds.
Loop-Down Code:	Repetitive 100, sent for 5.5 ± 0.4 seconds.

7.13.9.2 T1 Receiver Specifications

Connector

Connector Type:	WECO 310 jack.
Configuration:	Tip-Ring-Sleeve; Sleeve connected to ground, differential signal on Tip and Ring.

T1 Input Circuit

Input Impedance:	TERM position - 100 ohms ± 5%. BRIDGE position - 1000 ohms minimum.
Input Level:	± 3 volts (DSX-1) nominal, with 0 to 24 dB cable attenuation.

Data Rate Range:	1.544 Mb/s ± 500 b/s minimum.
Line Code:	Bipolar (pseudo-ternary), AMI with automatic detection of B8ZS coding.
Jitter Tolerance:	Meets jitter mask given in CCITT Recommendation G.703, in Bell PUB 41451, and PUB 62411.

7.13.9.3 Simplex Current Path

All specifications are for transmit (output) connector Tip and Ring shorted together and receive (input) connector Tip and Ring shorted together.

Current:	60 mA nominal, 145 mA maximum.
Voltage Drop:	7.3 ± 0.5 volts at 60 mA; jumperable to 2.8 volts maximum at 60 mA.
Polarity:	Bi-directional - either pair may be positive with respect to the other pair.
Break Down Voltage:	± 150 volts minimum from Tip and Ring to Chassis Ground.

7.13.9.4 Crystal Oscillator

Frequency:	1.54400 MHz.
Accuracy and Stability:	± 35 ppm (±54 Hz), 0°C to 50°C ambient.
Drift:	5 ppm per year typical.

SECTION 8
OPTIONS AND ACCESSORIES

8.1 INTRODUCTION

This section describes some of the options and accessories available for use with the FIREBERD. Information is provided on the PR-2000 Printer, Interface Switching Unit, Interface Switching Unit flush door accessory, rack mount, shipping case, soft carrying case, metal case option, metal case rack mount, and optional oscillators. Information is not provided on the IEEE Bus Option or interface modules since these are covered in Sections 6 and 7 of this manual.

8.2 PR-2000 THERMAL PRINTER

The PR-2000 is a quiet, non-impact, alphanumeric thermal printer. It is capable of printing the full-printable ASCII character set with up to 20 characters per line. The characters are input in a serial-asynchronous format with Start, Stop, and Parity bits. This small portable unit may be operated on a bench top or rack mounted along with the FIREBERD in the optional RM-1500A or RM-MC Rack Mount units. A cable is included with each printer allowing it to directly interface with the FIREBERD RS-232 Printer Interface at 2400 baud. For more information on the PR-2000 Thermal Printer, see the PR-2000 Operating Manual (ML10292).

8.3 ISU-2000 INTERFACE SWITCHING UNIT

The Interface Switching Unit (ISU) allows the user to change the FIREBERD interface module without physically removing and inserting the interface modules. The ISU is a rack-mountable device capable of housing up to four interface modules and electronically selecting one interface module for use with the FIREBERD.

Intended to be rack mounted either directly above or directly below the FIREBERD, the Interface Switching Unit is connected to the FIREBERD via a ribbon cable attached to a special interface adaptor (included). Switching between interface modules can be accomplished via pushbutton switches mounted on the ISU or remotely via contact closures. Indicators are provided on the ISU indicating which interface module is on line and whether the unit is under local or remote control.

The Interface Switching Unit will accommodate any of the FIREBERD interface modules and can be mounted with the interface facing the front of the rack (front access) or the rear of the rack (rear access). A BNC connector is mounted facing the front of the rack for the application of an external clock signal to the FIREBERD. The ISU can operate at 100/120/220/240 volts AC (50/60 Hz) and occupies 5 1/4" of rack height. For additional information on the Interface Switching Unit, see the ISU-2000 Operating Manual (ML 10312).

8.4 ISU FLUSH DOOR ACCESSORY (MODEL 10518)

The Interface Switching Unit (ISU) can be equipped with an optional Flush Door Accessory. The accessory recesses the ISU panel approximately 4 1/2 inches behind the rack mount surface and provides a smoke gray plexiglass door. The unit conceals the interface modules and cables while still allowing access to the interface module front panels.

8.5 RM-1500A RACK MOUNT

8.5.1 General Information

The RM-1500A allows the standard FIREBERD 1500A (plastic case) and the PR-2000 Thermal Printer to be mounted in a standard 19" equipment rack. The assembly requires 7" of vertical rack space. The Rack Mount provides a power switch for the Thermal Printer and an AC receptacle to provide AC power to both the FIREBERD and PR-2000 Thermal Printer.

WARNING: To minimize shock hazard, the Rack Mount chassis must be connected to an electrical ground. The Rack Mount is equipped with a three-conductor AC power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adaptor with grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet.

8.5.2 Installation Instructions

The following sections provide instructions for mounting the FIREBERD and PR-2000 Printer in the RM-1500A Rack Mount. If the FIREBERD has a swing-around handle, this handle must be removed before mounting into the Rack Mount. If the FIREBERD does not have a handle, proceed directly to the assembly instructions. If the FIREBERD does have a handle, the user may return the FIREBERD to TTC for handle removal, or to remove the handle use the following handle removal instructions.

Two different handles are presently in use, the plastic handle with the aluminum colored cross bar and the new all metal, all black handle. The removal instructions for each handle follow.

FIREBERD HANDLE REMOVAL (Plastic with Aluminum Cross Bar)

1. Disconnect the AC power cord from the FIREBERD.

2. Remove the left and right knurl nuts and the small springs on each side and spring the side arms enough to remove the handle assembly.

3. Lay the instrument on its top and remove the feet and four long screws.

4. Return the instrument to its upright position and carefully remove the top shell.

5. Remove the hex screw and side ratchet assembly from each side of the unit.

6. Make sure the upper PC board is in the third slot from the top in the card slides and remount the top shell making sure it "seats" in the side expanders and front and rear panels.

7. Lay the instrument on its top and reassemble the feet and four long screws. Do not overtighten the screws.

8. Return the instrument to its upright position. The FIREBERD is now ready for its rack mount assembly.

FIREBERD HANDLE REMOVAL (All Metal, Black Side Arms, and Cross Bar)

1. Disconnect the AC power cord from the FIREBERD.

2. Remove the left and right pushbutton and spring on each side (insert small screwdriver and pry gently). Remove the screw and washer from both sides. This will allow complete removal of handle and ratchet mechanism. The FIREBERD is now ready for rack mount assembly.

ASSEMBLY INSTRUCTIONS

1. Install the printer as follows:*

   a. Insert the PR-2000 through the Rack-Mount Panel from the front.

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* If a printer is not to be installed into the Rack-Mount unit, a blank-off plate is available to cover the Printer-Mounting hole.

b. Unlatch and slide the printer mechanism forward, exposing the printer mounting ears. Install four #4 x 3/16" large pan-head screws into the holes of the mounting ears then return the printer mechanism to its operating position (closed).

c. Install the printer-support bracket at the rear of the printer by removing the two #3 screws at the top, rear of the PR-2000. Attach the support bracket to the printer and chassis using four #4-40 x 3/16" large screws and lock washers.

2. Install FIREBERD as follows:

   a. Make sure the FIREBERD does <u>not</u> have the handle or side handle ratchet installed. The sides of the FIREBERD must be free of all handle components in order to fit into the rack adaptor.

   b. Place the FIREBERD on the shelf, front panel facing front, and carefully manipulate the front of the case through the opening. It should protrude through the front panel about 1/4 inch.

   c. Lift the rear of the FIREBERD and insert the two 1/4" hex x 3/16" large standoffs in the rear feet and align with two holes in the shelf. Install two #6 x 3/16" large screws and two lock washers through the bottom of the shelf into the standoffs.

   d. Install the two "Z" hold-down brackets at the rear of the instrument using the #4 hardware provided with the rack adaptor.

   e. Plug the FIREBERD and the printer into the 115-volts receptacle. The printer should be plugged into the receptacle that is controlled by the front-panel switch.

f. Fold and store excess FIREBERD and printer line cord under the printer. The bracket is designed to allow cable storage.

3. Connect the cable supplied with the printer from the 25-pin D-type connector on the rear of the printer to the RS-232 printer connector on the FIREBERD.

4. The RM-1500A unit should now be ready for rack installation. The unit will mount in a rack by its front panel without further angle brackets or supports.

8.6 SHIPPING CASE (MODEL 10176)

The shipping case holds a standard FIREBERD (plastic case), a PR-2000 Thermal Printer, five interface modules, accessory cables, and this manual. The rigid ABS molded case has a foam padded interior with cavities to hold the FIREBERD and its accessories. The case is tough and water resistant, and it has stainless steel draw latches and a molded handle. Case dimensions are 26 1/2" x 19" x 11 1/2".

8.7 SOFT CARRYING CASE (MODEL 10170)

The FIREBERD soft-side carrying case is constructed of canvas with dense foam inserts surrounding all sides, top, and bottom. The dimensions are 19 1/2" wide x 9 1/2" deep x 16 1/8" high. The case is navy blue and has an I.D. pocket on the top cover. The top cover is hinged and secured with Velcro fasteners. The case is carried by a handle that supports across the bottom and up both sides. Additionally, there is a padded, adjustable, snap-on shoulder strap.

The carrying case holds a standard FIREBERD 1500A (plastic case), a PR-2000 printer, three interface modules, and this manual, in addition to the associated cables and line cords. Empty, the case weighs 6 1/4 lbs.

8.8 FIREBERD MC1500A (METAL CASE OPTION)

The FIREBERD MC1500A is the ruggedized version of the standard FIREBERD 1500A. Performance characteristics, front- and rear-panel formats, and internal electronic sub assemblies are identical.

The FIREBERD MC1500A housing is of metal construction and quite rugged. The unit comes with a front cover. With the cover in place, the instrument is completely protected and can be carried and handled like a piece of luggage. This manual or two extra interface modules can be stored in the snap-on back pouch.

The FIREBERD MC1500A may be operated in a vertical or horizontal position. In the horizontal position, the handle folds down to elevate the front panel to a convenient viewing angle. When little space is available, the fold-out rear handles enable the unit to operate in a vertical position on the floor, with the interface module and cable installed.

The FIREBERD MC1500A is 6 1/2" high (including the feet), 14 1/2" wide, and 14" deep (including the cover). With the cover, the unit weighs 18 lbs.

8.9 FIREBERD MC1500A RACK MOUNT (MODEL RM-MC)

8.9.1 General Information

The RM-MC allows the FIREBERD MC-1500A (metal case) and the PR-2000 Thermal Printer to be mounted in a standard 19" equipment rack. The assembly requires 7" of vertical rack space. The Rack Mount provides a power switch for the Thermal Printer and an AC receptable to provide AC power to both the FIREBERD and PR-2000 Thermal Printer.

WARNING: To minimize shock hazard, the Rack Mount chassis must be connected to an electrical ground. The Rack Mount is equipped with a three-conductor AC-power cable. The power

cable must either be plugged into an approved three-contact electrical outlet or used with a three contact to two-contact adaptor with grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet.

8.9.2 Installation Instructions

The following sections provide instructions for mounting the FIREBERD and PR-2000 Printer in the RM-MC Rack Mount. If the FIREBERD has a swing-around handle, this handle must be removed before mounting into the Rack Mount. If the FIREBERD does not have a handle, proceed directly to the assembly instructions. If the FIREBERD does have a handle, the user may return the FIREBERD to TTC for handle removal or use the following handle removal instructions to remove the handle.

FIREBERD HANDLE REMOVAL (Metal Case Units)

1. Disconnect the AC power cord from the FIREBERD.

2. Remove the left and right pushbutton and spring on each side (insert small screw driver and pry gently). Remove the screw and washer from both sides. This will allow complete removal of handle and ratchet mechanism. The FIREBERD is now ready for rack-mount assembly.

ASSEMBLY INSTRUCTIONS

1. Install the printer as follows:*

   a. Insert the PR-2000 through the Rack-Mount Panel from the front.

b. Unlatch and slide the printer mechanism forward, exposing the printer-mounting ears. Install four #4 x 3/16" large pan-head screws into the holes of the mounting ears then return the printer mechanism to its operating position (closed).

2. Install FIREBERD as follows:

   a. Make sure the FIREBERD does not have the handle installed. The sides of the FIREBERD must be free of all handle components in order to fit into the rack adaptor.

   b. Place the FIREBERD on the shelf, front panel facing front, and carefully manipulate the front of the case through the opening. It should protude through the front panel until the lip of the bezel fits solid.

   c. Install the two "Z" hold-down brackets at the rear of the instrument using the #4 hardware provided with the rack adaptor.

   d. Plug the FIREBERD and the printer into the AC receptacle. The printer should be plugged into the receptacle that is controlled by the front-panel switch.

   e. Fold and store excess FIREBERD and printer-line cord under the printer.

3. Connect the cable supplied with the printer from the 25-pin D-type connector on the rear of the printer to the RS-232 printer connector on the FIREBERD.

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* If a printer is not to be installed into the Rack-Mount unit, a blank-off plate is available to cover the Printer-Mounting hole.

4. The RM-MC unit should now be ready for rack installation. The unit will mount in a rack by its front panel without further angle brackets or supports.

8.10 OPTIONAL CLOCKS

Up to four user-specified frequencies may be provided in the FIREBERD. These clocks are selected by the FA, FB, FC, and FD positions of the GENERATOR CLOCK TX(RCV) switch. Each oscillator is available at frequencies ranging from 100 Hz to 13 MHz.

The options are as follows:

Option 003	One Additional Internal Clock Rate
Option 004	Two Additional Internal Clock Rates
Option 005	Three Additional Internal Clock Rates
Option 006	Four Additional Internal Clock Rates

Each oscillator provides frequency which is accurate to within ± 1 ppm at 25° C, ± 5 ppm, stability from 0° C to 40° C, and 5 ppm typical aging per year. The frequency of any of the oscillators may be periodically aligned to within ± 1 ppm by TTC-authorized personnel. Refer to the label on the rear of the FIREBERD for the optional oscillator positions.

SECTION 9
MAINTENANCE AND SERVICE

9.1 IN CASE OF DIFFICULTY

If the unit fails to operate and no front- or rear-panel indicators illuminate, check the following:

AC power cord and AC supply
AC fuse and fuse size

If some indicators illuminate but the unit fails to operate, verify that the interface module in use is the correct type and properly inserted (turn off power before inserting or removing the interface module). Check the interface cable and connections to the FIREBERD. Try substituting another interface module if one is available.

Follow the Self Test Procedure in Section 3 as an aid to localizing the problem. If the unit cannot be made to operate properly, refer to the following sections for service information or call the TTC Customer Service department for applications assistance.

9.2 WARRANTY POLICY

All equipment manufactured by Telecommunications Techniques Corporation (TTC) is warranted against defects in material and workmanship. This warranty applies only to the original purchaser and is non-transferable unless express written authorization of the warranty transfer is granted by TTC.

FIREBERD mainframes (models 1500A, MC1500A, 2000, MC2000, 2000-1, and MC2000-1) shipped after March 31, 1985, will be repaired or replaced (at our option) at no charge for a period of three (3) years after original receipt by the customer. All units shipped after March 31, 1985 have serial numbers greater than or equal to 4000 for ease of identification.

Data interfaces, accessories, cables, breakout boxes, and all equipment other than FIREBERD mainframes will be repaired or replaced (at our option) at no charge for a period of one (1) year after original receipt by the customer.

Liability under this warranty extends only to the replacement value of the equipment. This warranty is void if:

1. Equipment has been altered or repaired without specific authorization by TTC.

2. Equipment is installed or operated other than in accordance with instructions contained in TTC literature and operating manuals.

No other warranty is expressed or implied. TTC is not liable for consequential damages.

9.3 IN-WARRANTY SERVICE

Units in warranty must be returned to the factory with shipping prepaid and should be packed and shipped in accordance with the instructions contained in Section 9.5 of this manual. Defective units will be repaired or replaced (at our option) depending on severity of defect. Prior to returning any equipment, the customer must obtain a Return Authorization (RA) number by contacting the TTC Customer Service department. Once issued, the RA number should appear on all paperwork and be clearly marked on the outside of the equipment container.

Upon completion of repairs, the unit will be tested to applicable specifications and burned-in for at least 24 hours, retested, and returned to the customer with shipping prepaid. A brief description of the work performed and the materials used will be provided on the Equipment Repair Report furnished with the returned equipment.

9.4 OUT-OF-WARRANTY SERVICE

The procedure for repairing out-of-warranty equipment is the same as that used for units still in warranty. However, there is a minimum charge of $75.00 applied to each request for out-of-warranty service. The $75.00 minimum charge guarantees the customer an estimate of the repair costs and is used as credit against actual materials and labor costs should the equipment be repaired. The customer will be billed for parts plus standard labor rates in effect at the time of repair and will be required to furnish a purchase order number before repair work can be started. A description of the labor and materials used will be provided in the Equipment Repair Report.

9.5 EQUIPMENT RETURN INSTRUCTIONS

With all equipment returned for repair, attach a tag indicating the following:

1. Owner's name and address.

2. A list of the equipment being returned and the applicable serial number(s).

3. A detailed description of the problem or service requested.

4. The name and telephone number of the person to contact regarding questions about the repair.

5. The Return Authorization (RA) number.

If a FIREBERD mainframe is being returned, it is recommended that all switches be left in the positions they were in when the problem occurred, and that the interface module in use at the time of the failure also be returned.

If possible, the unit should be returned using the original shipping container and material. If the original container is not available, the unit should be carefully packed so that it will not be damaged in transit. TTC is not liable for any damage that may occur during shipping. The customer should clearly mark the TTC-issued RA number on the outside of the package and ship it prepaid and insured to TTC's Repair Department.

APPENDIX A
ABBREVIATIONS

APPENDIX A - ABBREVIATION

async	asynchronous
BER	bit error rate
blk	block
blk error	block error
b/s	bits per second
clk	clock
CS	Clear To Send
CTS	Clear To Send
DCE	data communications equipment
DM	Data Mode
DSR	Data Set Ready
DTE	data terminal equipment
DTR	Data Terminal Ready
err	error
err sec	error second
ext	external
gen	generator
Hz	Hertz
inv	invert
isoch	isochronous
I/F	interface
k	kilo (1000)
kHz	kilo Hertz
LL	Local Loopback
Mb/s	million bits per second
MHz	mega Hertz
min	minute
NSEC	Nanosecond
MK	mark
pp	peak-to-peak
ppm	part per million
rcv	receive
RL	Remote Loopback

RLSD	Receive Line Signal Detect
RR	Receiver Ready
RS	Request To Send
RTS	Request To Send
sec	second
sp	space
sync	synchronous
TM	Test Mode
TR	Terminal Ready
TTC	Telecommunication Techniques Corporation
TX	transmit
v	volts

APPENDIX B
IEEE-488 SAMPLE PROGRAM

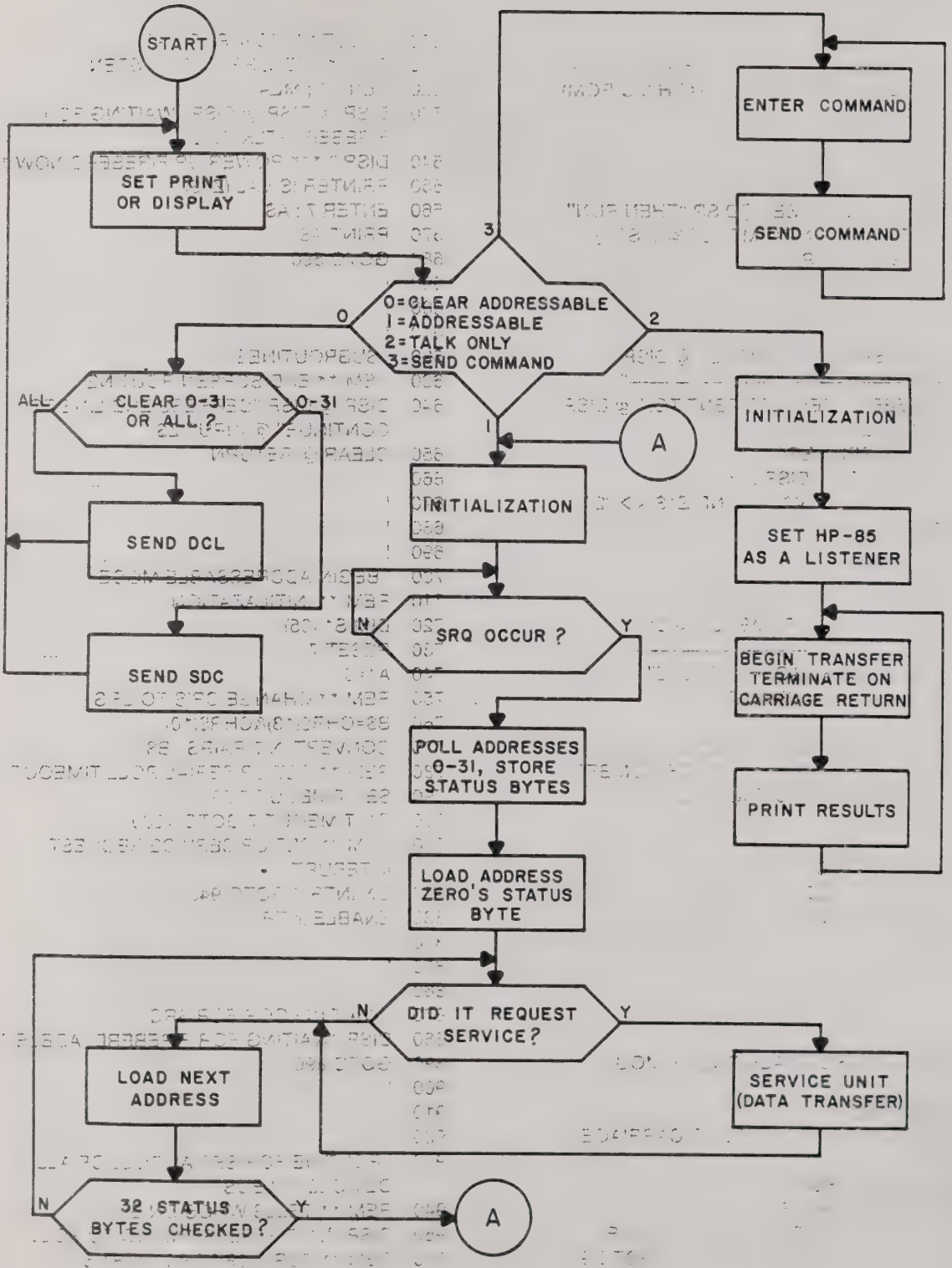
The following program provides a method for extracting data results from a FIREBERD 1500A via the IEEE-488 Bus. It is also designed to send miscellaneous commands to the 1500A. The program is designed to operate on a HP-85 BASIC computer with the I/O ROM option installed.

In Addressable mode, it will operate with up to 15 FIREBERDS at once by serial polling all FIREBERDS then servicing each one in sequence. This program allows 50 ms for each device on the bus to complete the polling procedure. If the poll is not completed in the specified amount of time, the HP-85 will determine that there is not a device connected at that address and will continue the polling sequence. Once all status bytes are stored, the program will begin servicing units sequentially starting at address zero.

The program is designed to display a line of data once the carriage return has been received. If within 2 seconds a carriage return is not received and after at least one line of data has been displayed, the computer will terminate the transfer and continue on to service the next unit. Once all requesting units are serviced, the program waits for another service request to be initiated.

In Talk Only mode, this program performs simple printer functions and will operate with only one FIREBERD on the bus at a time.

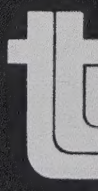
NOTE: To shorten entry of this program into a computer, line numbers preceding a "REM" (Remark) statement or an exclaimation point (!) may be omitted.


START
SET PRINT OR DISPLAY
0=CLEAR ADDRESSABLE
1=ADDRESSABLE
2=TALK ONLY
3=SEND COMMAND
3
0
2
1
CLEAR 0-31 OR ALL?
ALL
0-31
SEND DCL
SEND SDC
INITIALIZATION
SRQ OCCUR ?
N
Y
POLL ADDRESSES 0-31, STORE STATUS BYTES
LOAD ADDRESS ZERO'S STATUS BYTE
DID IT REQUEST SERVICE?
N
Y
LOAD NEXT ADDRESS
SERVICE UNIT (DATA TRANSFER)
32 STATUS BYTES CHECKED?
N
Y
A
A
ENTER COMMAND
SEND COMMAND
INITIALIZATION
SET HP-85 AS A LISTENER
BEGIN TRANSFER TERMINATE ON CARRIAGE RETURN
PRINT RESULTS

```
10  ! PROGRAM-"MAN48A"
20  ! WRITTEN-10/14/82
30  ! REV     -A
40  !
50  ! THIS PROGRAM IS DESIGNED FOR USE ON
    AN HP-85 BASIC COMPUTER (WITH I/O ROM)
60  !
70  !
80  !
90  CLEAR @ BEEP
100 DISP "DEPRESS PAUSE" @DISP "THEN RUN"
    @ DISP "TO RETURN TO MENU" @ DISP @
    DISP @ DISP @ DISP
110  GOSUB 640
120 !
130 !
140 CLEAR @ DISP @ DISP "MENU" @ DISP
    "_____"
150 DISP "FIREBERD RESULTS SENT TO:" @ DISP
160 DISP "   1 . . . DISPLAY"
170 DISP "   2 . . . PRINTER"
180 ! * Z1$ IS PRINT OR DISPLAY
190 INPUT Z1$ @ IF Z1$ <> "1" AND Z1$ <> "2"
    THEN 140
200 !
210 !
220 !
230 CLEAR @ DISP @ DISP "MENU" @ DISP
    "_____"
240 DISP "   0 . . . CLEAR ADDRESSABLE"
250 DISP "   1 . . . ADDRESSABLE"
260 DISP "   2 . . . TALK ONLY"
270 DISP "   3 . . . SEND COMMAND"
280 DISP @ DISP "ENTER APROPRIATE NUMBER"
    @ DISP "AND DEPRESS ENDLINE"
290 INPUT Z$ @  CLEAR
300 IF Z$="1" THEN 700
310 IF Z$="2" THEN 400
320 IF Z$="0" THEN 2080
330 IF Z$="3" THEN 2130
340 GOTO 230
350 !
360 !
370 !
380 !
390 ! INITILAZATION FOR TALK ONLY Y MODE
400 RESET 7
410 DIM A$[20], B$[2]
420 REM ** CHANGE LINEFEEDS TO CARRIAGE
    RETURNS
430 B$=CHR$(13)&CHR$(10)
440 CONVERT IN 7 PAIRS; B$
450 REM ** SET TIMEOUT FOR A LONG TIME
460 SET TIMEOUT 7;0 @ ON TIMEOUT 7 GOTO 90
470 !
480 !
490 !
500 ! ROUTINE TO INPUT DATA
510 REM ** TELL HP-85 TO LISTEN
520 SEND 7 ; MLA
530 DISP @ DISP @ DISP "WAITING FOR
    FIREBERD (TLK ONLY)"
540 DISP " *** POWER UP FIREBERD NOW *** "
550 PRINTER IS VAL (Z1$)
560 ENTER 7 ; A$
570 PRINT A$
580 GOTO 560
590 !
600 !
610 !
620 ! SUBROUTINES
630 REM ** END SCREEN ROUTINE
640 DISP @ DISP "DEPRESS END LINE TO
    CONTINUE" @ INPUT Z$
650 CLEAR @ RETURN
660 !
670 !
680 !
690 !
700 ! BEGIN ADDRESSABLE MODE
710 REM ** INITILAZATION
720 DIM S1 (35)
730 RESET 7
740 A1=0
750 REM ** CHANGE CR'S TO LF'S
760 B$=CHR$(13)&CHR$(10)
770 CONVERT IN 7 PAIRS ; B$
780 REM ** SET UP SERIAL POLL TIMEOUT
790 SET TIMEOUT 7;50
800 ON TIMEOUT 7 GOTO 1200
810 REM ** SET UP SERVICE REQUEST
    INTERUPT
820 ON INTR 7 GOTO 940
830 ENABLE INTR 7;8
840 !
850 !
860 !
870 ! WAIT IN LOOP FOR SRQ
880 DISP "WAITING FOR FIREBERD (ADBLE)"
890 GOTO 890
900 !
910 !
920 !
930 ! ROUTINE FOR SERIAL POLL OF ALL
    DEVICES ON BUS
940 REM ** TELLS WHOS ON BUS
950 DISP "UNIT(S) RESPONDING TO POLL"
960 REM ** TURN OFF SRQ INTRT'S
```

```
970  OFF INTR 7
980  REM ** CLEAR ALL POLL LOCATIONS
990  FOR I=0 TO 31
1000 S1(I)=0 @ NEXT I
1010 REM **
1020 ! BEGIN POLLING PROCEDURE
1030 ! THIS SERIAL POLL WILL DETECT 1ST SRQ,
     POLL ALL DEVICES, THEN SERVICE THE 1ST
     REQUEST 0-31
1040 ! IT WILL SERVICE THE NEXT SEQUENTIAL
     ADDRESS WHICH SENT A SERVICE REQUEST
1050 ! ANY ADDRESS POLLED WITH NOTHING ON
     THE BUS WILL BE SKIPPED
1060 !
1070 !
1080 FOR I=0 TO 31
1090 REM ** SKIP SPOLL OF HP-85
1100 IF I=21 THEN 1140
1110 S1=SPOLL (700+I)
1120 DISP I;
1130 S1(I)=S1
1140 NEXT I
1150 DISP @ DISP @ DISP
1160 GOTO 1270
1170 !
1180 !
1190 ! HERE IF NO ONE RESPONDS TO THE SRQ
1200 ABORTIO 7 @ GOTO 1140
1210 !
1220 !
1230 !
1240 ! ROUTINE TO CHECK STATUS BYTES OF
     EACH RESPONDING ADDRESS AND JUMP
     FOR SERVICE
1250 !
1260 !
1270 FOR I1=0 TO 31
1280 REM ** TEST FOR STATUS BYTE
     FIREBERD=(64)
1290 IF S1(I1)=64 THEN 1470
1300 NEXT I1
1310 !
1320 !
1330 REM ** IF ALL 31 ADDRESSES WERE
     SERVICED START OVER
1340 IF A1=1 THEN 1360
1350 PRINTER IS 2 @ PRINT "ERROR CONDITION"
     @ PRINT "SRQ SENT BUT NO ONE
     RESPONDED" @ GOSUB 640 @ GOTO 90
1360 GOTO 720
1370 !
1380 !
1390 REM ** HERE IF NO STATUS BYTES WERE
     RECOGNIZED
1400 PRINTER IS 2
1410 CLEAR @ PRINT "ERROR CONDITION" @
     PRINT "NO RECOGNIZABLE STATUS BYTES"
     @ PRINT "WERE RECEIVED"
1420 GOSUB 640 @ GOTO 720
1430 !
1440 !
1450 !
1460 ! DISPLAY WHO SENT SRQ
1470 PRINTER IS VAL (Z1$)
1480 PRINT @ PRINT "ADDRESS"; I1; "SENT THIS
     PRINT"
1490 PRINT "_____
     _____"
1500 !
1510 !
1520 !
1530 ! BEGIN DATA XFER
1540 REM ** ALLOW 2000 MS FOR A DATA
     TRANSFER
1550 OFF TIMEOUT 7
1560 SET TIMEOUT 7; 2000
1570 ON TIMEOUT 7 GOTO 1790
1580 REM ** WHEN A1=1, MEANS AT LEAST ONE
     DATA XFER WAS OK
1590 A1=0
1600 PRINTER IS VAL (Z1$)
1610 !
1620 !
1630 REM ** ENTER TERMINATES ON LF'S OR E
1640 ENTER 700+I1 USING "%,K"; A$
1650 !
1660 !
1670 !
1680 ! * PUT DATA TESTS IN HERE
1690 IF A$= "BUFFER FULL" THEN BEEP @ BEEP
     @ BEEP @ BEEP
1700 !
1710 PRINTER IS VAL (Z1$)
1720 PRINT A$
1730 REM ** SET TO 1 AT LEAST ONE GOOD
     TRANSFER
1740 A1=1
1750 GOTO 1640
1760 !
1770 !
1780 !
1790 ! HERE TO DECIDE IF END OF XFER WAS EOI
     OR LF
1800 REM ** JUMP IF TIME OUT DUE TO EOI
1810 IF A1=1 THEN 1910
1820 !
1830 !
1840 !
1850 PRINTER IS 2
1860 CLEAR @ PRINT @ PRINT "DATA TRANSFER
     NOT COMPLETED" @ PRINT "TOOK MORE
     THAN 2.0 SEC"
```

```
1870  PRINT "POWER UP FIREBERD" @ GOSUB 640
      @ GOTO 90
1880  !
1890  !
1900  !
1910  ! ONLY GETS HERE IF DATA IS OK AND EOI
      WAS RECEIVED
1920  DISP "EOI" @ BEEP @ BEEP
1930  !
1940  !
1950  !-----------------------------------
1960  REM ** RESET HP-85'S HP-IB
1970  RESET 7
1980  !
1990  !
2000  !
2010  REM ** IF < 31 GO CHECK THE REST OF
      THE STATUS BYTES
2020  IF I1 < 31 THEN 1300
2030  GOTO 790
2040  !
2050  !--
2060  !
2070  ! ROUTINE TO CLEAR
2080  CLEAR @ DISP @ DISP "WHICH ADDRESS
      WOULD" @ DISP "YOU LIKE TO CLEAR
      (0-31) OR ALL"
2090  ON ERROR GOTO 2080 @ INPUT Z$@ IF
      Z$="ALL" THEN CLEAR 7 ELSE CLEAR VAL
      (Z$)+700
2100  OFF ERROR @ GOTO 140
2110  !
2120  !
2130  !
2140  ! ROUTINE TO SEND COMMANDS
2150  C1$="PRFC" @ U1$="0"
2160  CLEAR
2170  DISP
2180  DISP "ENTER COMMAND AND
      ADD RESS OF"
2190  DISP "UNIT TO RECEIVE COMMAND"
2200  DISP "-----------------------------
      ------------------------"
2210  DISP "SUCH AS:  PRFC, 8 OR CLEAR, 3"
2220  INPUT C$,U$
2230  ! REPEAT LAST COMMAND ON NULL
2240  IF C$=" " OR U$=" " THEN C$=C1$ @ U$=U1$
2250  IF C$#" " AND U$#" " THEN C1$=C$ @
      U1$=U$
2260  SET TIMEOUT 7 ; 2000
2270  ON TIMEOUT 7 GOTO 2330
2280  IF C$="CLEAR" THEN CLEAR 700+VAL (U$) @
      GOTO 2310
2290  OUTPUT 700+VAL (U$) USING "#,K" ; C$
2300  OUTPUT 700+VAL (U$) USING "#,B" ; 13
2310  CLEAR @ DISP @ DISP @ DISP @ DISP
      "COMMAND SENT . . . "; C$," "; U$ @ WAIT
      800
2320  GOTO 2160
2330  CLEAR @ DISP "**** COMMAND NOT SENT
      ****" @ BEEP
2340  DISP @ DISP "TRY AGAIN" @ GOSUB 640
2350  RESET 7 @ GOTO 2160
```



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